COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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February, 1945

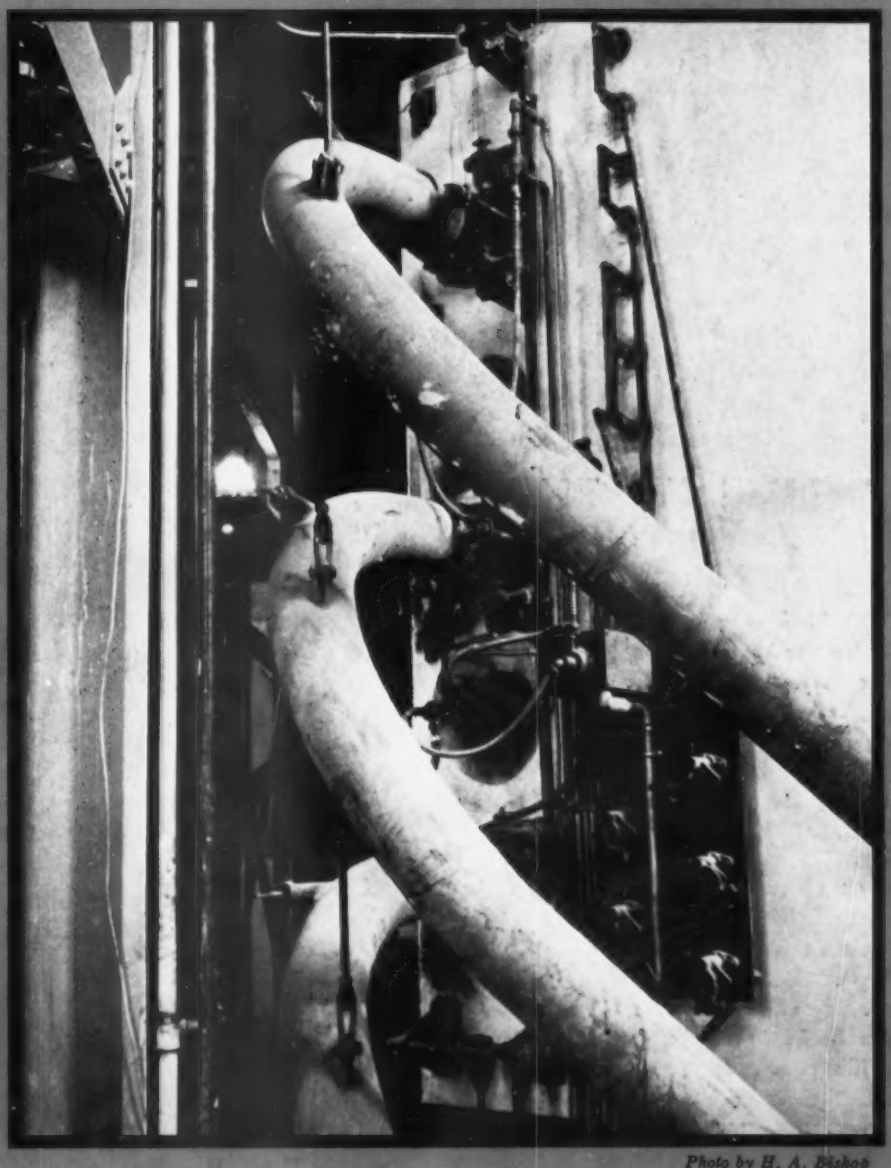

Photo by H. A. Bishop

Corner firing showing controls for burners and dampers

Brooklyn Navy Yard's New Power Plant

Heat Flux Pattern in Fin Tubes Under Radiation

DON'T GIVE UP THE SHIPS

FROM the days of John Paul Jones and the *Bon Homme Richard* America has taken a just pride in her Navy. But two modern wars have shown us that merchant ships are as vital to our national safety as fighting ships. Twice in our history we've had a fine merchant marine. And each time we lost it. No enemy took our ships from us — *we gave them up.*

In the 1830's nine-tenths of our foreign trade was carried in American ships. But national apathy brought about a complete reversal, and by 1910 foreign ships were carrying nine-tenths of our foreign trade.

At the outbreak of World War I we frantically began building up our depleted merchant marine to transport urgently needed troops and supplies. And at the close of the war American ships were carrying 11 million gross tons annually.

But again we allowed our strength in merchant shipping to deteriorate, and by the middle thirties foreign ships were carrying 75 per cent of our foreign trade, and millions of dollars that should have gone to American shipping and seamen were paid to foreign shipping interests.

Today — thanks to the U. S. Maritime Commission and our vast shipbuilding industry — we have by far the largest merchant marine in the world and an estimated post-war fleet of over 50 million deadweight tons. This time we cannot afford to lose it — not merely because it will have cost us 18 billion dollars, but because it means the maintenance of our economic and military safety in the post-war world.

For the Merchant Marine, now hastening the day of victory, will also help to expand our foreign trade, maintain our productive capacity, provide post-war employment and preserve our national standard of living. This time, let's not give up the ships, for only national apathy and lack of foresight can take them away from us. Let's preserve *the American Merchant Marine.*

★ ★

It has been the privilege of Combustion Engineering to supply marine boilers for many hundreds of American cargo vessels and tankers. This organization pledges the continuance of its best efforts for the maintenance and upbuilding of the American Merchant Marine so that it may remain second to none in size, speed and efficiency. We believe this objective deserves the interest and support of every American citizen. A-855

C-E INSTALLATIONS span the entire range of steam generating requirements from small stoker-fired boilers of less than 50 horsepower to the largest power station units.

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME SIXTEEN NUMBER EIGHT

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EDITORIAL

War's Toll of Power Plants

It is impossible at present to assess the destruction of power plants in many parts of the world that has been wrought to date by the war; and further destruction is certain before the last gun has been fired or the last bomb dropped. Because their output is vital to war production, and as their stacks present distinctive targets, power plants have been primary objectives of attack.

Military censorship has precluded the release of much information on this subject, but it is generally known that power stations suffered heavily in Italy, as well as in certain sections of western Europe. Those in England, during the earlier stages of the war, were reported from time to time to have sustained some damage, and those in France to a lesser degree. As the German armies rolled eastward through Russia, and in their subsequent retreat, the destruction in their wake obliterated most of the power facilities in those areas, which were established in connection with Russia's industrialization program of the thirties. Damage in the Balkan countries, from outside attack and sabotage, has probably been considerable. Finally, the incessant air attacks on Germany over the past two years must have exacted a considerable toll of power installations, despite the Germans' precautions of scattering their sources of power supply. Her pre-war information on power plants was carefully guarded, even as early as 1936, at the time of the last World Power Conference.

Aside from actual destruction, much power equipment in Europe has undoubtedly suffered severe depreciation under the stress of war demands. The major part of the initial task of rehabilitating Europe's power facilities will fall upon the United States, and to a lesser extent upon England and perhaps Switzerland. Up to the present, our contribution has been principally under Lend-Lease; although, as conditions permit, direct purchases are likely to follow. Aside from the vast number of portable and semi-portable plants of limited capacity that have already been shipped, many larger plants of a permanent nature are now in various stages of design and construction. These are reported to aggregate several million kilowatts capacity and thus far the majority are destined for Russia, although other countries will come in for their share.

Before the war, Germany held a dominant position in many continental markets for power equipment, along with Switzerland and Czechoslovakia. Her post-war position in this field will be influenced by the terms of peace; but, whatever these may be, it is doubtful if she will be able to regain her former position for many years, if at all. Meanwhile, American-made equipment of all kinds will have gained acceptance. However, the permanency of such markets for our products should not be taken for granted. After the first few post-war years, some of those countries will be in a position to build heavy equipment to meet their current and future needs; whereas markets in other countries will depend largely upon government policy, world economic conditions, and the attitude of American manufacturers toward maintaining their customers' good will in the face of competition from a revived European industry. Therefore, prospects of the present and the immediate post-war period must not, in themselves, form the sole basis of future expectations. They will serve as an entreé that will require following through if certain permanent markets are to be attained.

The Ban on Conventions

Widespread approval appears to have been accorded the announcement by the Director of War Mobilization that, subsequent to February first, special permission will be required for holding conventions or conferences involving attendance of more than fifty people, unless such meetings are of a local nature. This ruling is especially welcome to those who, in the course of essential business travel, have experienced the present inconveniences of overburdened transportation and hotel facilities.

Last year, despite appeals by the ODT, many conventions were held in lines entirely foreign to or only remotely connected with the war effort; although a few organizations did show their patriotism by canceling scheduled meetings. Now, application must be made in all cases and only those that can be fully justified before the War Committee on Conventions are to receive the necessary permission. This is one of several measures by means of which it is hoped to avoid the imposition of travel rationing.

It may be contended that most engineering meetings have bearing on prosecution of the war, and some unquestionably do; but there are now fewer in this category than two or three years ago when war production was getting under way and there was consequently greater need for the exchange of ideas and experiences. Of course, as the war progresses, new problems arise. Some of these are currently discussed in the technical press and in this way much of the essential information is made available to those who can profit by it; others can well be handled by local panel discussions or engineering clinics.

As we are about to go to press, word has been received that permission has been denied for holding the Annual Midwest Power Conference, scheduled for April 9 and 10 at Chicago.

One partial solution to the present ban on national and regional meetings would lie in more comprehensive local programs, with special attention directed to technical developments and economic matters growing out of the war.

Brooklyn Navy Yard's New Power Plant

By WILLIAM H. WELSH

Master Mechanic, U. S. Navy Yard, New York, N. Y.

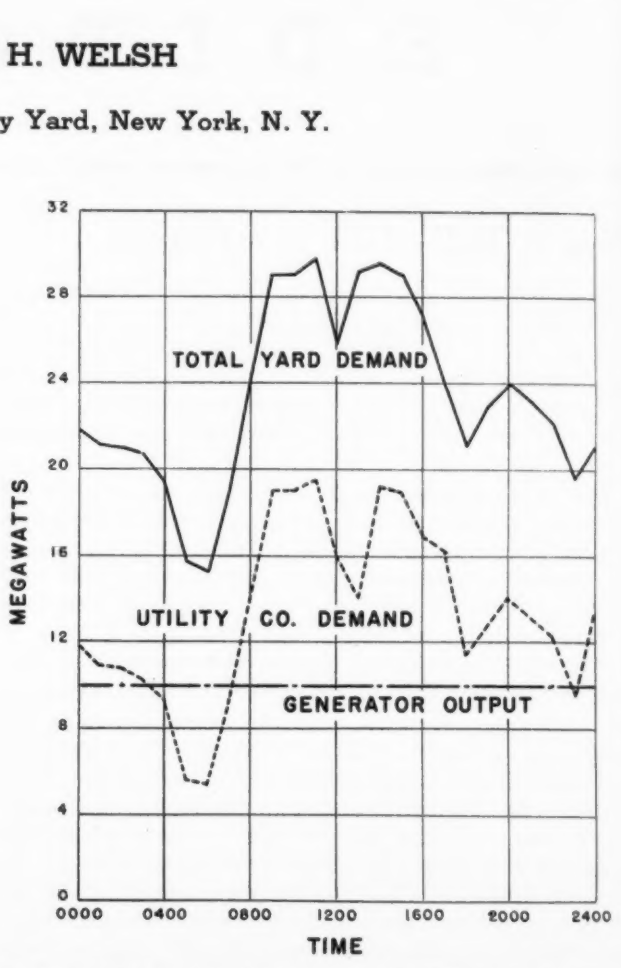
To meet the increasing war demands for a variety of power, steam, compressed air and pumping demands, the ten low-pressure boilers were replaced by six modern 400-psi stoker-fired units; two of the existing turbine-generators were retained and high-pressure machines ordered to serve as topping units. It was necessary to keep the old units in service while the new plant was being constructed on the same site. Part of the electrical load is generated and part purchased.

FEW war industries can match a large Navy Yard as to the diversity of services supplied by the power department and the varying demands upon it. The construction of large war vessels calls for vast amounts of electric power to operate cranes, to supply innumerable welding outfits and to serve the many shops in which various components are fabricated; also large quantities of compressed air. Similarly, the repair and overhaul of ships create heavy demands for such services. There is also a large pumping load when ships are being dry-docked; and when vessels are in for repair and overhaul they frequently shut down their own power plants and take steam, electricity and compressed air from the yard lines. All this is in addition to supplying the different buildings with light, heat, power, fire protection, etc.

The power plant at the Brooklyn Navy Yard formerly contained ten boilers, with an aggregate steam-generating capacity of 300,000 lb per hr at 175 psi pressure, five condensing extraction-type turbine-generators of 14,000 kw total rated output, one 2500- and two 5000-cfm air compressors and other equipment. The electrical capacity was supplemented with power purchased from the local utility.

With the approach of war it became apparent that this plant would be inadequate to meet the heavy demands upon the yard; hence, studies were initiated to expand its facilities.

In view of the age and low pressure of the existing equipment and boilers, it was decided to replace them with six new units of greater capacity and operating at approximately 400 psi and 725 F total steam temperature. Two existing 6000-kw and 2500-kw Elliott turbine-generators were to be retained to operate through reducing valves from the new boilers until installation of two new 7500-kw turbine-generators, ordered to top these two 175-psi units, which would then make a total installed generating capacity of 23,500 kw.



Typical daily electrical load curve, the difference between the two curves representing that generated by the plant. Note Army-Navy time is employed

The purchased energy was to be continued to supplement that generated and to provide a dual supply as a safety factor. Three 15,000-kva, 27/13-kv tie substations, seven 9000-kva, 13/2.3-kv main distribution substations, and local 2300-volt distribution substations in various new buildings were added to the electrical distribution system, all centrally controlled and interconnected with main and supervisory control boards at the Central Power Plant.

Furthermore, it was decided to erect a new power house on the same site which necessitated keeping the old plant in service while the new structure was being built and the new boilers installed. At the present writing the new boilers are in service and one 7500-kw turbine-generator is in the process of erection. Of the total present average power demand of 26,000 kw about a third is being generated and two-thirds purchased.

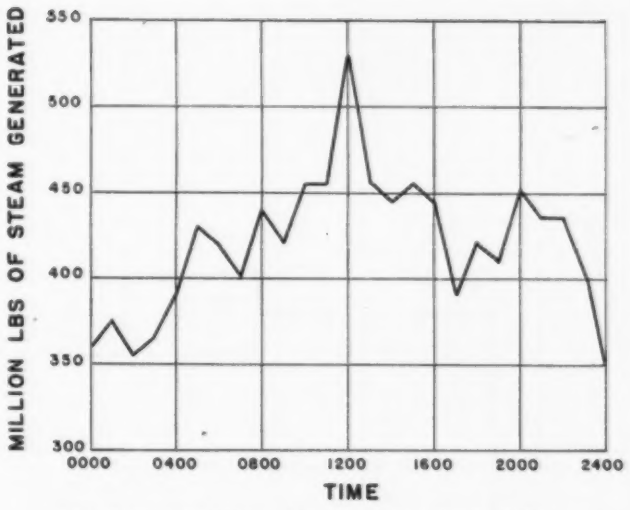
The new boilers are stoker-fired inasmuch as oil firing, aside from the desire to conserve oil, would have necessitated oil storage facilities that would have been difficult at this site and would have increased the hazard in the event of aerial attack.

Five of the boilers are of the Combustion Engineering three-drum design, fired with C-E multiple-retort stokers, and the sixth is a four-drum Riley unit which was

removed from the original power plant and reinstalled in the new power plant. It is fired with a Westinghouse multiple-retort stoker. Each boiler is designed for 450 psi (405 psi operating pressure at the superheater outlet) and 725 F steam temperature. The rated continuous capacity of each boiler is 150,000 lb of steam per hour and 165,000 lb per hour for two-hour peaks when operating with feedwater at 220 F. The first C-E unit was completed in July 1942 and the four others in May 1943; the Riley unit having recently been completed in its new location.

The units were designed to burn eastern bituminous coal of 13,940 Btu heating value, 2600 F ash-fusion temperature, 8.1 per cent ash, 1.8 per cent sulphur and 2.6 per cent moisture as received; but recent conditions in the fuel market have made it necessary to depart from these coal specifications.

The C-E boilers have 60-in. steam drums, plain 3-in. front water walls, finned-tube rear walls and water-cooled clinker chills extending along the stoker sides. Each has 13,530 sq ft of boiler heating surface, 1800 sq ft of water-wall surface, 3110 sq ft of superheater surface (Elesco interbank type), 6915 sq ft of economizer surface, a furnace volume of 6045 cu ft and a furnace heat release of 37,200 Btu per cu ft at rated capacity. Each is equipped with ten 2-in. Diamond automatic-valved revolving type soot blowers and six Clyde retractable type for blowing the boiler surfaces and eight 2-in. revolving type blowers for the economizers. Two 4-in. and one

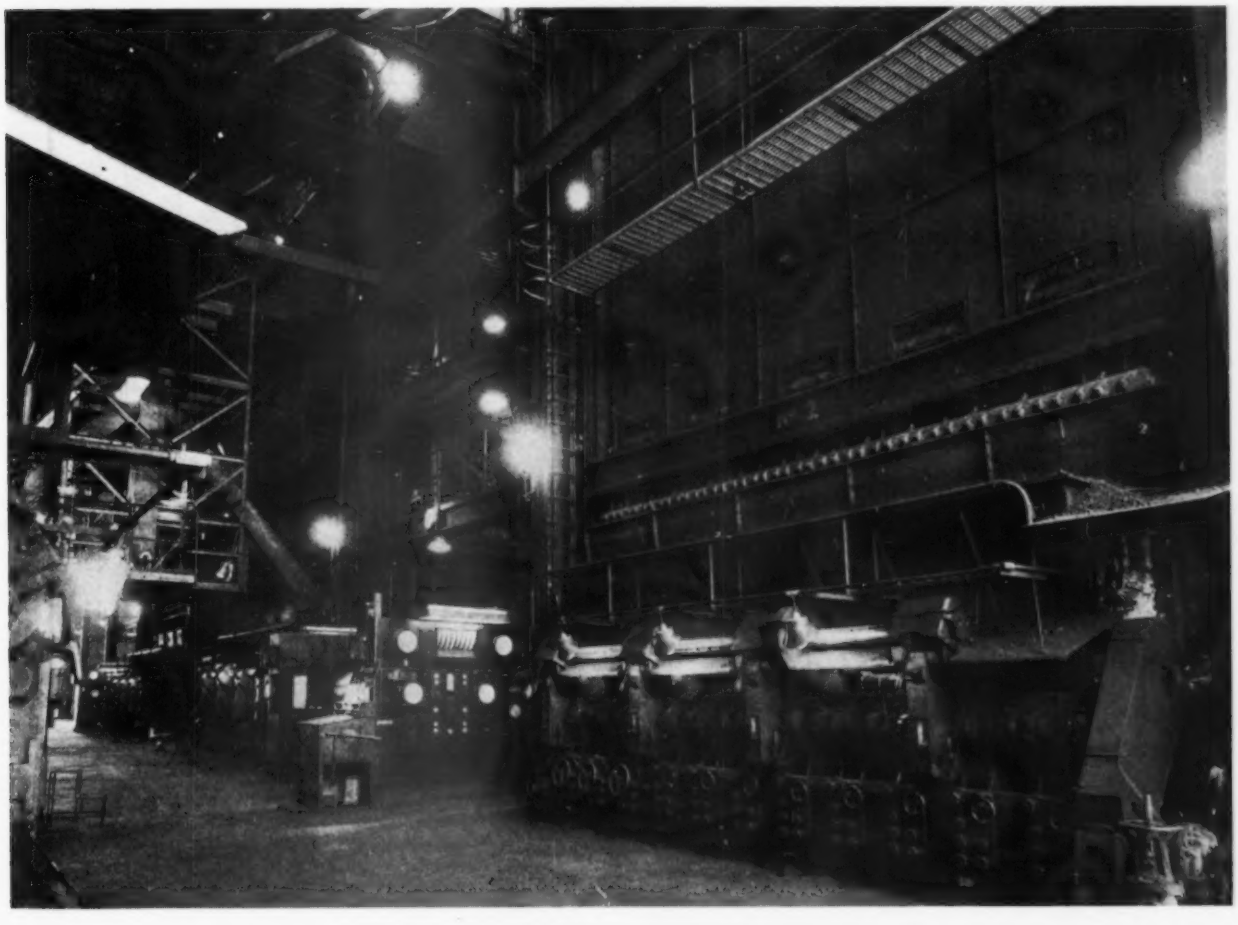


Variation in steam demand for a typical day

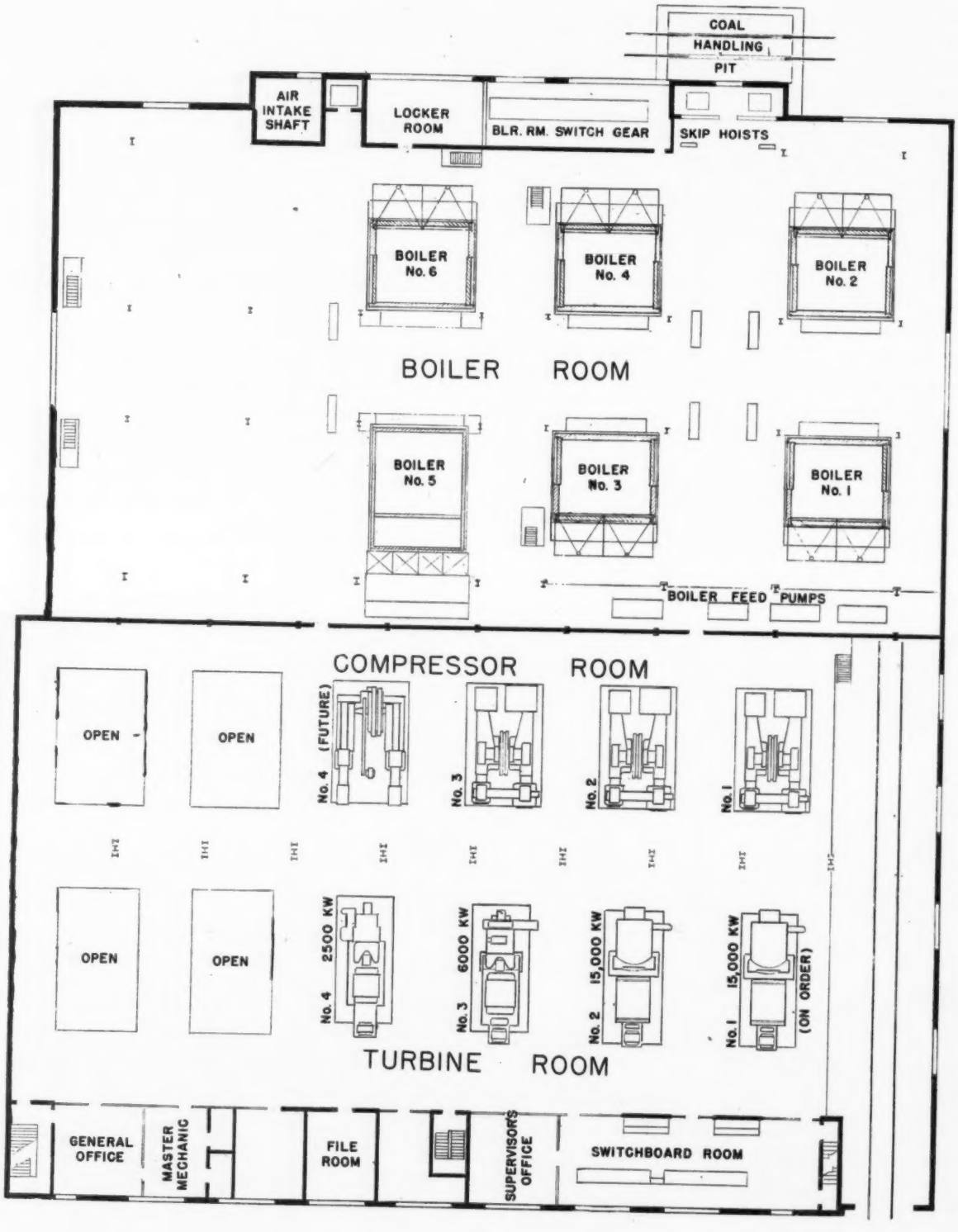
$1^1/_2$-in. Consolidated safety valves are employed on each boiler. All are equipped with combustion control which can be operated fully automatic or manual; CO_2 recorders; boiler meters of the steam flow—air flow type with temperature recorders; boiler-water meters and all necessary draft gages.

Forced draft is supplied by 60,000-cfm fans.

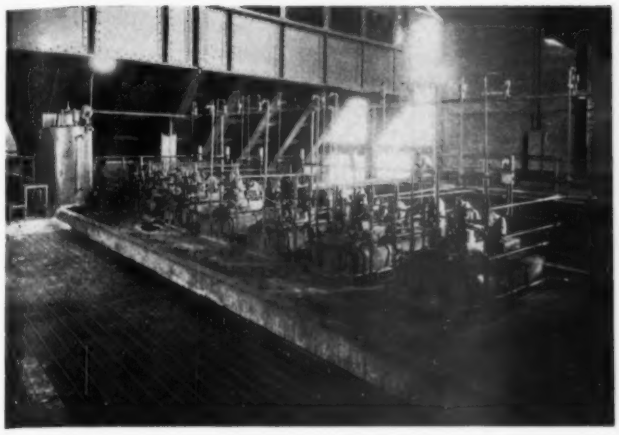
Ash is sluiced by an Allen-Sherman-Hoff system into a storage tank with decanter.



Firing aisle and one row of boilers



Plan of main operating flow



Row of proportioner pumps for feedwater treatment

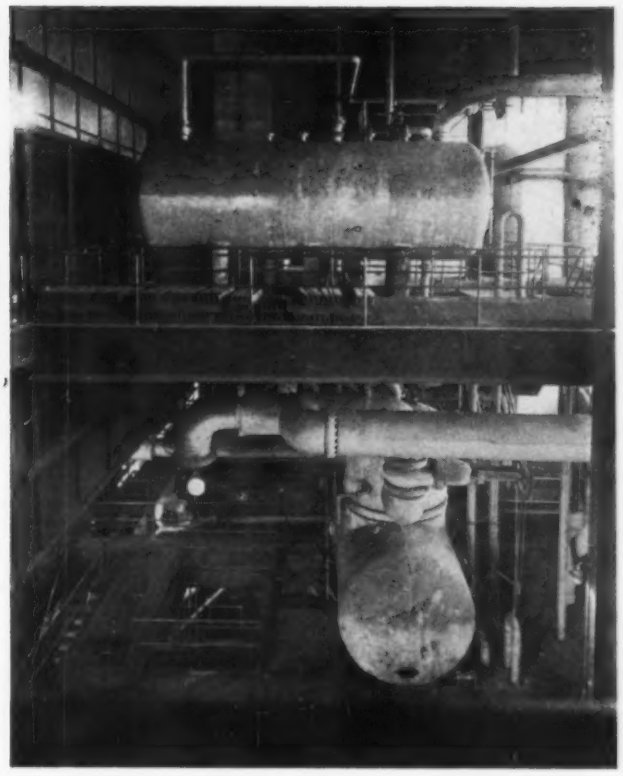
Feedwater and Treatment

Makeup is supplied by zeolite automatic water softeners having a capacity of 192,000 gallons each. The makeup and condensate are stored in two 8000-gallon surge tanks which supply three 225,000-lb per hour deaerating feedwater heaters in which 4 lb steam pressure is employed to heat the boiler water to 222 F. Caustic is added by a separate pump for each boiler ahead of the economizer to keep the pH from 8.5 to 9.5 and the alkalinity in the boiler water from 75 ppm to 125 ppm. Phosphate is added directly into the boiler by a separate pump, this is maintained at 100 to 200 ppm. Each boiler is equipped with a continuous blowdown. Total solids of boiler water is maintained at 1200 to 1500 ppm. In case of failure in water supply there is installed an emergency tank of 35,000 gallons capacity which cuts in automatically to the surge tanks.

Ash Disposal and Cinder Catchers

Ash is sluiced from the boilers and then pumped into a 90-cu yd cast-iron storage tank with decanters elevated so that ash can be removed into cars or trucks.

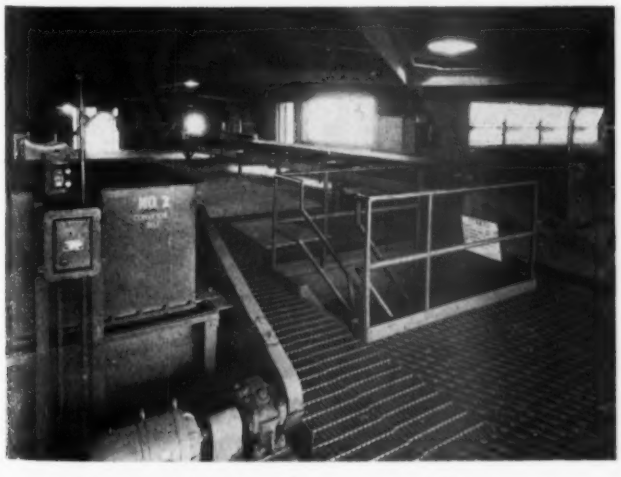
The fly-ash cinder-catcher system is of the baffle type (Green) installed on each boiler and designed to handle 110,000 cfm of flue gas and recover not less than 80 per cent of the cinder and fly ash.



One of the feedwater heaters, with surge tank on level above

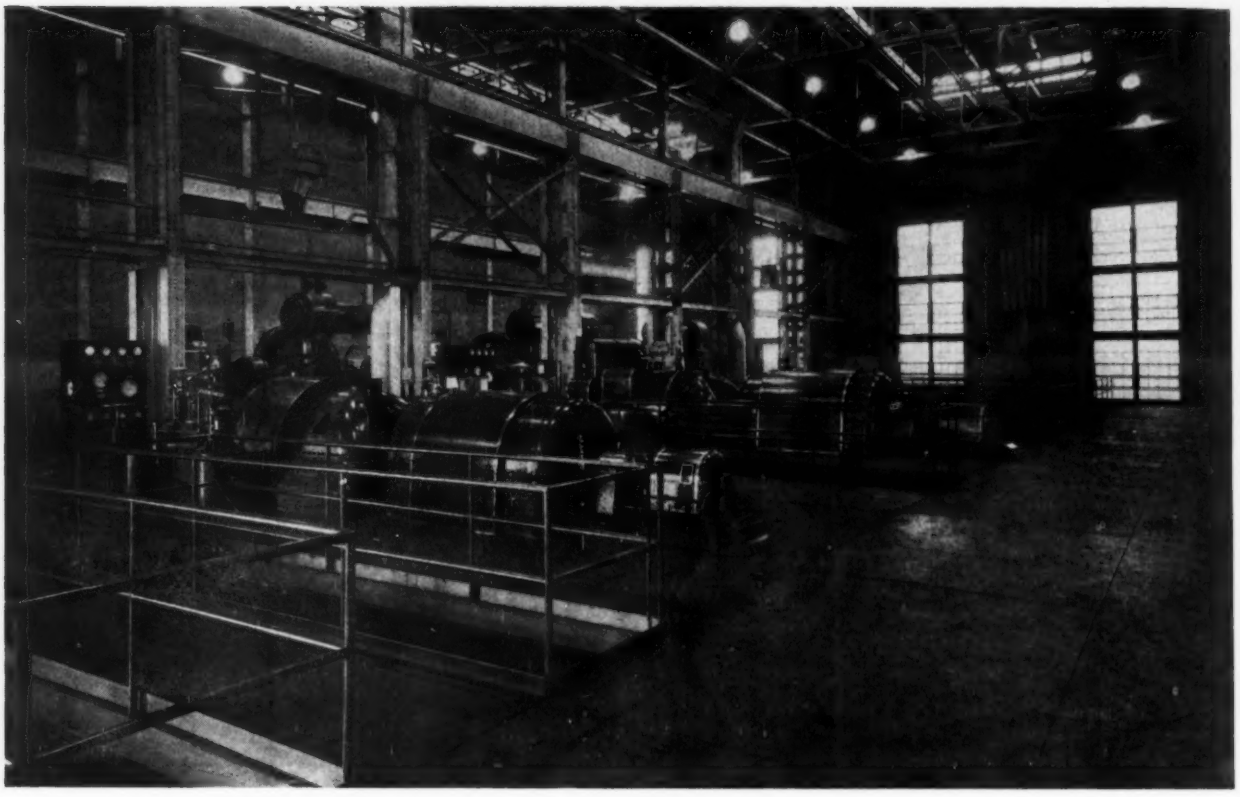
Coal Handling

Coal is delivered to the plant in cars from which it is dumped into two receiving hoppers. These hoppers supply two automatic skip hoists, each of 3 tons capacity, which can deliver 250 tons per hour. Crushers are installed for run-of-mine coal, but these are bypassed for nut and slack. Feed conveyors with magnetic pulleys deliver the coal to two 36-in. belts which transfer it into two flight conveyors. These are reversible so that coal may be stored in various parts of a 3750-ton bunker. Weigh larries of five tons capacity deliver the coal to the stoker hoppers from the bunker. These can be seen in the view of the firing aisle.



Feed conveyors which deliver coal to belt conveyors

Conveyors which distribute coal to bunkers



Turbine room with compressor room in background
(At the time this picture was taken, December 28, 1944, the first of the two 7500-kw turbine-generators had not been erected)

Additional Data on New Equipment

New turbine-generators
Westinghouse—Inlet pressure 400 psi
Inlet temperature 700 F
Exhaust, 28 in. hg vacuum
Extraction pressure, No. 1—175 psi
Extraction pressure, No. 2—25 psi
3600 rpm
13,800 volts, 3-phase, 60 cycles
9375-kva, 392 amp
Exciter, 125 volts, 340 amp

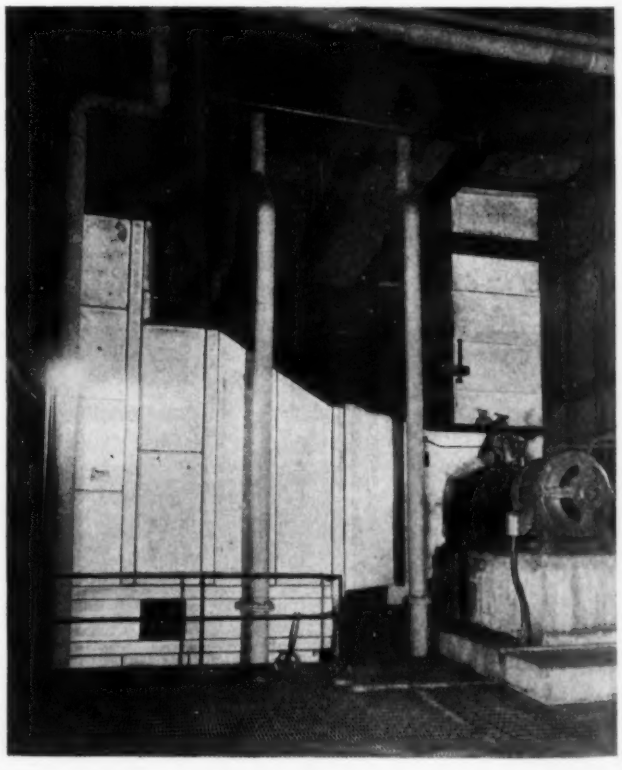
Forced-draft fans serving Combustion Engineering boilers, each 60,000 cfm at 100 F, 5 in. w.g.
Green Economizer Co. type driven through magnetic coupling by 75-hp. induction motor operating at 440 volts, 3 phase, 60 cycles, 95 amps, 1180 rpm.
Induced-draft fans, each of 110,000 cfm at 410 F, 6 in. w.g. driven through magnetic coupling by a 200-hp, 2200 volt, 3-phase, 60-cycle, 700-rpm induction motor.

Fans for Riley boiler
Two Sturtevant forced-draft fans each of 30,000 cfm at 100 F, 5 in. w.g., with vane control and driven by 30-hp, 3-phase, 440-volt, 60-cycle, 1160 rpm motors.
Induced-draft fan of 110,000 cfm at 410 F, 6 in. w.g. driven by a 200-hp 3-phase, 2200-volt, 700-rpm induction motor through a magnetic coupling.

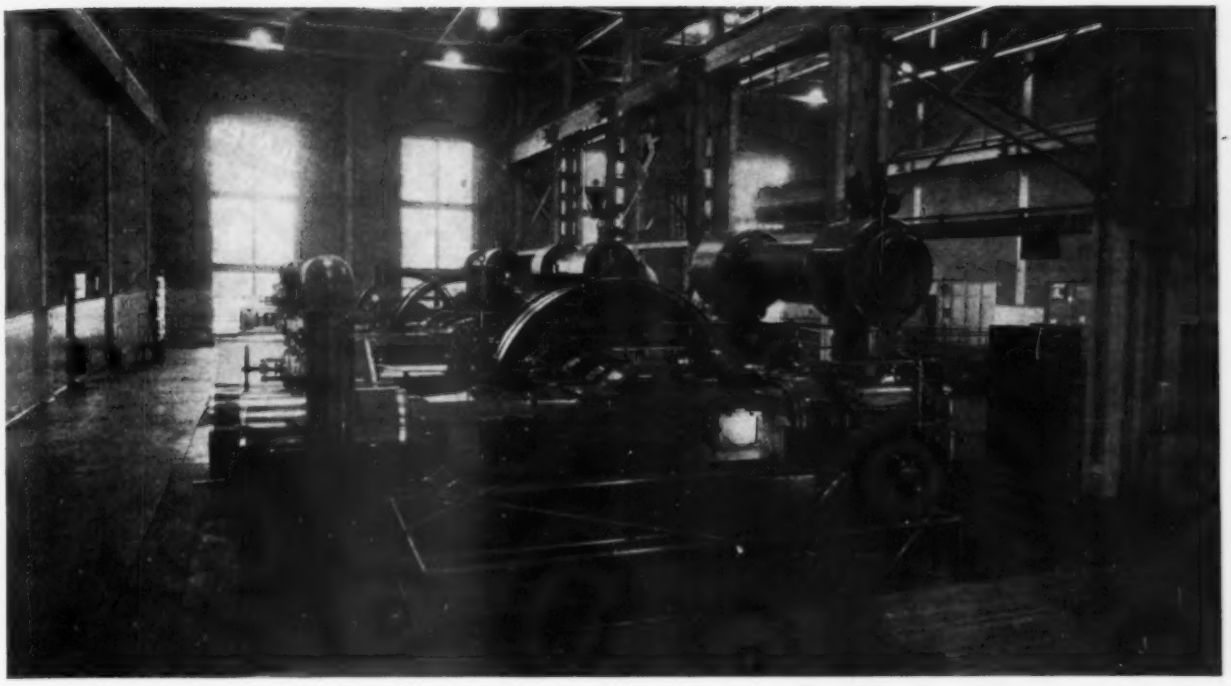
Westinghouse stoker drive for Riley boiler
Turbine—Westinghouse

Generated voltage
Installed 6000-kw unit, 2300 volts, 60 cycles, 3 phase
2500-kw unit, 2300 volts, 60 cycles, 3 phase
Under construction, 7500-kw unit 13,800 volts, 60 cycles, 3 phase

Distribution voltage to substations
a.c. 13,800–2300–440–220–110
d.c. 220–100



One of the induced-draft fans and breeching



This compressor room contains three 5000-cfm machines

Capacity and type of air compressors
Three 10,000-cfm, driven by 2000-hp, 2300-volt, 3-phase, 60-cycle synchronous motors
One 5000-cfm, driven by 1000-hp, 2300-volt, 3-phase, 60-cycle synchronous motor
Two 2500-cfm, driven by 500-hp, 2300-volt, 3-phase, 60-cycle synchronous motors
The above motor-driven compressors are not at present located in the compressor room of the power plant
Three 5000-cfm, driven by compound engines, operating at 175 psi steam at 475 F with exhaust of 26-in. vacuum. One of these was in the old plant.

Pressure at which air is distributed
100 psi

Desuperheating station and reducing stations
Three of 150,000 lb per hr at 400 psi 725 F to 175 psi at 475 F
One of 250,000 lb per hr at 400 psi 725 F to 175 psi 475 F

These supply steam for the low-pressure turbines, air compressors, two standby fire pumps, service to ships, and industrial use by shops.

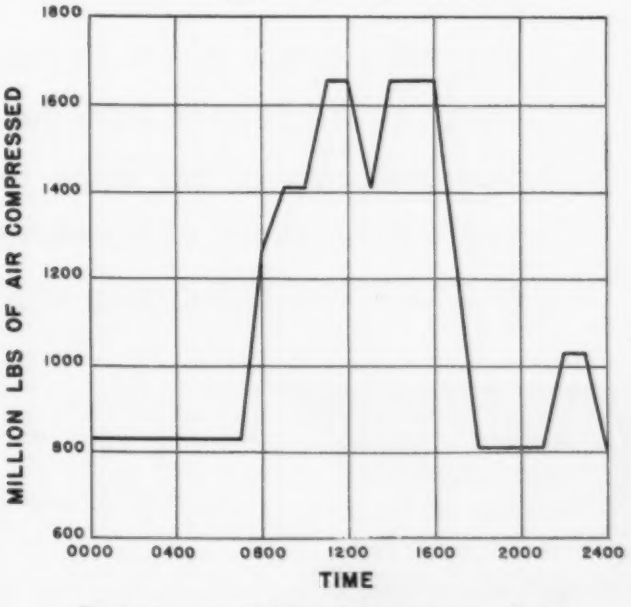
One of 200,000 lb per hr at 400 psi 725 F to 25 psi 300 F

This steam, also turbine extraction and exhaust from the fire pumps, house pumps, feed pumps and other auxiliaries, is used for building heating, feedwater heating or other services requiring low-pressure steam. Connected radiation is 1,560,500 sq ft.

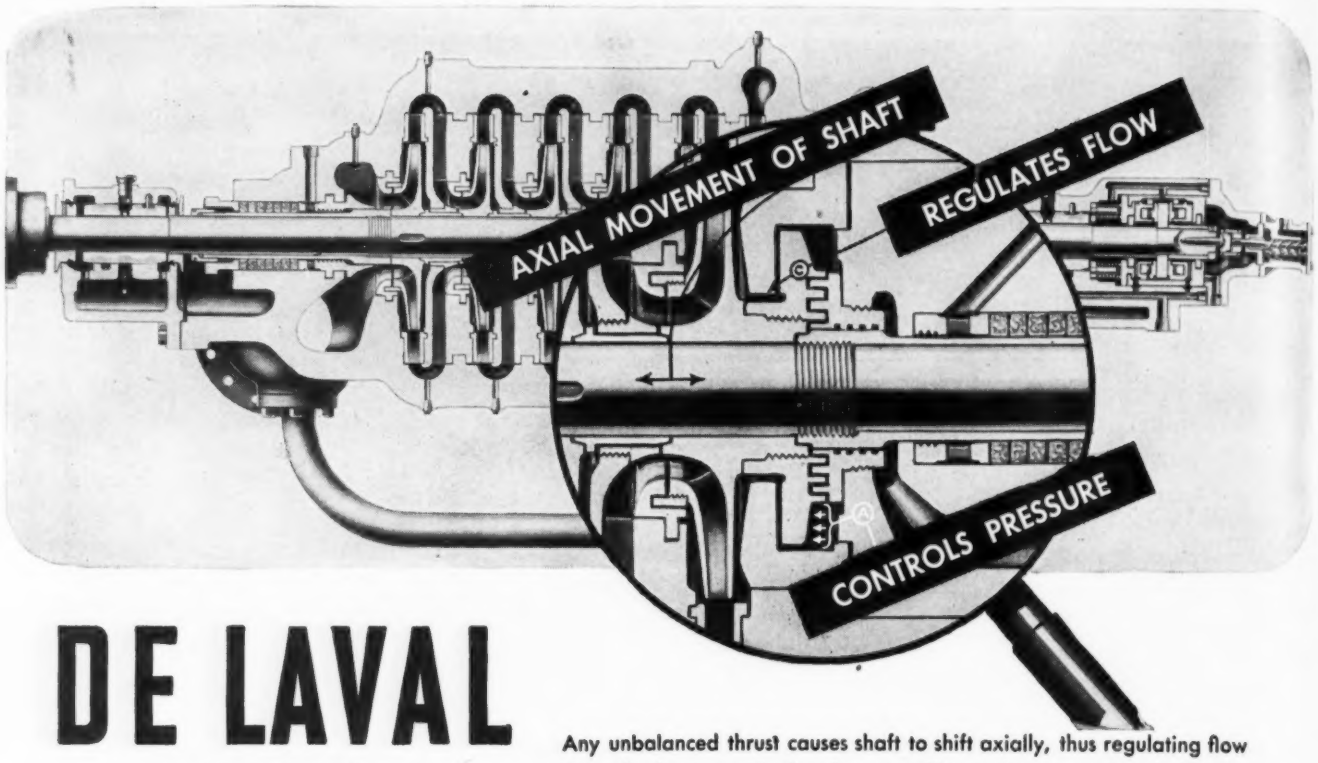
Electric, compressed air and steam loads

	Minimum	Maximum
Electric	18,000 kw	32,000 kw
Steam	250,000 lb per hr	600,000 lb per hr
Compressed air	10,000 cfm	50,000 cfm

View in switchboard room



Typical curve of demand for compressed air



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Any unbalanced thrust causes shaft to shift axially, thus regulating flow through clearance C, thereby controlling pressure against balancing disc A and thus automatically returning the pump to a state of perfect balance. Note that this hydraulic device leaves no unbalanced thrust to be taken up by bearings or other metallic contacts subject to wear.

ELIMINATES SOURCE OF TROUBLE IN HIGH-PRESSURE BOILER FEED PUMPS

The erosive action of high-temperature feed water in a high-pressure boiler-feed pump does not interfere with the operation of the De Laval automatic hydraulic balancing arrangement, since the automatic action of this device is in no way affected by normal wear, as can be seen from the illustration. Its universally trouble-free performance has been demonstrated over a period of 30 years in hundreds of installations, handling feed water up to 350° F. and discharging against pressures up to 1600 psi.

3630

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Heat-Flux Pattern in Fin Tubes Under Radiation*

By A. R. MUMFORD and E. M. POWELL

Combustion Engineering Company, Inc.

The following curves represent the results of temperature measurements on the semi-circumference of finned furnace tubes in a tangentially fired slagging-bottom furnace under varying conditions of slag accumulations; also a laboratory approach to the study of heat-flux pattern in which electrical measurements were employed.

A NUMBER of examples of the use of surface temperatures to indicate the heat-flux variation around the circumference of a tube have appeared in the technical publications. Although this method is fascinating and gives promise of producing data which will aid in our more complete understanding of what is going on in the furnace and at the walls, it is apparent that the variations caused by slag deposits in coal-fired furnaces are of such magnitude that a much larger amount of data than are at present available will be required before one can say with assurance that this or that condition represents the normal at a given location and rating.

Fig. 1 represents a plan section through a furnace having a slagging bottom and fired tangentially with pulverized coal. The furnace walls are made up of finned tubes one of which, as indicated, was selected for the measurement of surface temperatures. Thermocouples were installed at several points around the circumference of the tube at an elevation of approximately 13 ft from the floor of the furnace.

Fig. 2 contains a number of curves showing the difference between the tube surface temperature and the saturation temperature around the exposed semi-circumference of that tube at intervals after the unit was lighted off.

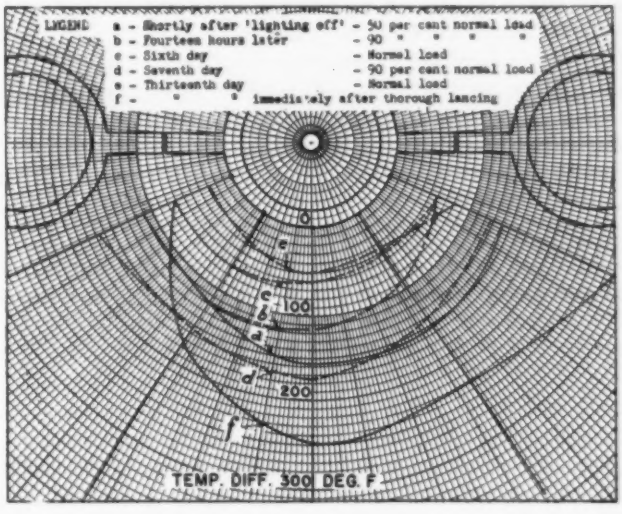
LEGEND
a - Shortly after 'lighting off' - 50 per cent normal load
b - Fourteen hours later - 90 " " " "
c - Sixth day - Normal load
d - Seventh day - 90 per cent normal load
e - Thirteenth day - Normal load
f - " " immediately after thorough lancing
100
200
TEMP. DIFF. 300 DEG. F

Fig. 2—Curves showing difference between tube surface temperature and saturation temperature

* From a paper presented at the Annual A.S.M.E. Meeting on November 30, 1944.

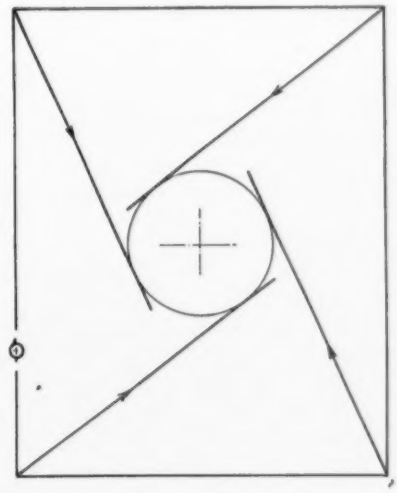

Fig. 1—Diagrammatic plan of tangentially fired slagging-bottom furnace

Curve *a* represents the condition shortly after lighting off when the load was less than one-half normal. Little coal had been burned up to that time and it is probable that the tube surface was clean and exposed. The temperature elevation varies about 50 deg F with the peak at or to the right of the normal to the wall. Fourteen hours later the boiler was operating at about 90 per cent of normal and no lancing had been done. Some ash had accumulated on the surface because the surface temperature of the metal had dropped as shown on curve *b* despite the fact that the rate of heat release in the furnace had doubled. It may be significant that the greater drop in surface temperature occurred in the right-hand quadrant of the tube. At least this quadrant is the point at which one would expect ash to deposit from an examination of the geometry of the furnace, noting the direction of the fuel stream and the point of highest heat intensity.

Curve *c* represents the conditions about six days after the boiler was lighted. The load was normal but ap-

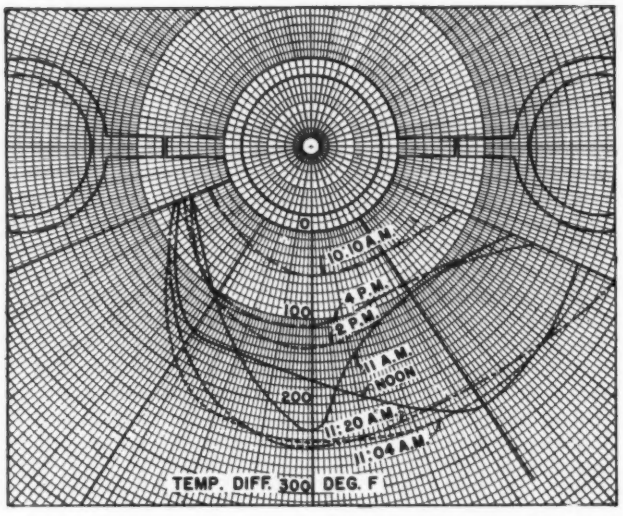

Fig. 3—Temperatures before and after lancing

parently a fairly uniform coating of ash had accumulated, which reduced the rate of heat transfer to such a point that the surface temperature of the tube was only 60 to 70 deg F above saturation.

Curve *d* represents conditions one week after the unit was lighted off, and with only routine lancing and with a load of about 90 per cent of normal. This curve is of particular interest because of the small variation around the circumference. The evidence of these observations would indicate that the normal temperatures would be higher in the right-hand quadrant.

Six days later, or thirteen days after lighting off, the conditions are represented by curve *e*. These surface temperatures are the lowest observations at full load and and indicate the existence of a heavy coating of slag with more heat being transmitted through the right-hand quadrant. This curve represents the condition immediately preceding a thorough lancing of the walls.

Curve *f* represents conditions immediately after the wall had been lanced. The largest temperature drop, and probably the largest rate of heat transfer, exists in the right-hand quadrant. The comparatively low drop which is shown at 30 deg from the face of the wall in the left-hand quadrant is probably due to the continued adherence of some insulating slag in this region.

A more detailed examination of the period immediately preceding and following the lancing of the wall is shown on Fig. 3. The wall in the region of this particular tube was lanced between 11 a.m. and 11:20 a.m., and the changes in heat transfer are indicated by the temperature differences. At 10:10 a.m., before lancing, the average temperature difference was 50 deg F, that in the left-hand quadrant being somewhat lower. At 11 a.m., at the start of lancing, the temperature difference through the tube wall on a normal to the plane of the furnace wall increased to 230 deg F with lesser increases at other points. If the rate of heat transfer is taken as proportional to the temperature drop, then the rate at the front face of the tube immediately after lancing is 4.7 times that before lancing. At 11:14 a.m., what is indicated as the cleanest condition was reached and this was practically unchanged at 11:20 a.m. when the lancing had been completed. At noon, 2 p.m. and 4 p.m. the rate of accumulation of the insulating layer of ash is indicated by a decreasing temperature difference. A better appreciation of the changes taking place will be realized by noting the location of this tube in Fig. 1, with relation to the approaching coal stream and the zone of highest heat intensity off the right-hand quadrant and the lance coming from the left.

In Figs. 2 and 3, zero of the temperature scale is at the tube surface and each inch radially thereafter is equal to 100 deg F. The elevation within the furnace at which these temperatures were taken is in the zone of high heat release and slag deposits. Therefore, although these temperatures are not representative of the entire furnace, they do serve as a good indication of the variations which can take place in the zone of intense heat transfer during operation. Conclusive study of the heat-flux pattern in a finned tube would require the collection of field data, not only over a long period in a coal-fired furnace, but over many areas of the furnace in which insulating layers of slag are or are not deposited.

On Fig. 4 are plotted several curves which show the temperature differences which existed at various times on the circumference of the tube and at the extremity of one fin. The temperature scale is the same as used in Figs. 2 and 3. The variations of surface temperature are most pronounced at the tip of the fin and on the tube wall adjacent to the fin. Except for the general rise which occurred after 11:30, the variations in the quadrant at the left were comparatively small, but those at the right were so much that the most feasible explanation is the dropping off of a fairly dense layer of slag. The method of presentation does not take into consideration the fact that the metal thickness between the measuring point and the internal fluid is greater by one inch for the fin temperature point. If it were certain that the entire fin had been exposed a heat flux proportional to the temperature drop per inch of metal could have been assumed, but since one could not be

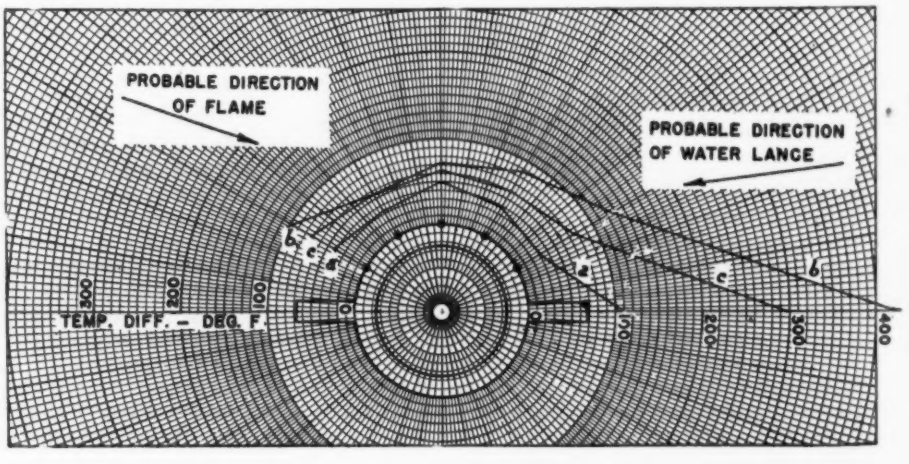

Fig. 4—Temperature variations at tube surface and fin extremity

sure of this with the data available, no attempt was made at making a correction.

Obviously, the variations occurring in this zone of the furnace preclude any short-time study of heat-flux patterns by field measurements in a coal-fired furnace. It should be pointed out that the conditions shown on Figs. 2, 3 and 4 are not representative of the entire furnace, but only of the flowing slag zone of a slagging-bottom pulverized coal furnace. The conditions at other furnace wall areas are known to be less variable. Evidence of the variation to be expected in different areas of the furnace is given in the paper by Henry Kreisinger and R. C. Patterson entitled "Heat Transfer to Water-Cooled Furnace Walls." presented before the Annual Meeting of the A.S.M.E. in 1943. The variable conditions in the slag zone, however, will set the requirements for the testing period because the slag zone is about 10 per cent of the furnace area.

The laboratory approach to the problem of heat-flux pattern in finned tubes under radiation permits a determination of temperature drops by analogy and, therefore, the determination of heat-flux patterns without the

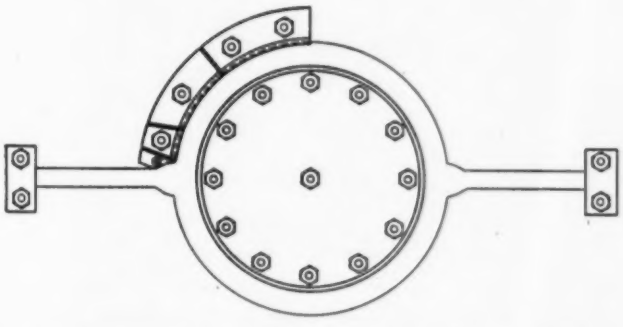

Fig. 5—Diagram of apparatus for producing voltage drop across simulated finned tube wall

interference of ash deposits. Fig. 5 represents a test setup used for the purpose of studying these flux patterns with particular emphasis on the flow of heat from the base of the fin through the tube wall. On a sheet of high-resistance alloy, cut in the shape of a section of a finned tube, a number of radial and circumferential lines were machined scribed. Electric currents were passed through the sheet in such values as to be comparable to the heat flow by radiation. By noting voltage drop, amperes and electrical conductivity as equivalent to temperature drop, quantitity of heat per unit of time and thermo-conductivity, rsepectively, temperature drops could be computed from the electrical measurements. Voltage drops were measured at the intersections of the scribed lines and the analogous temperature computed.

Fig. 6 shows the calculated temperature distribution at the base of a fin $^1/_4$-in. × 1 in. long on a 4-in. × 0.380-in. tube, and Fig. 7 shows the distribution at the base of a fin $^1/_4$ in. × $^{11}/_{16}$ in. long on the same tube. In each case the current flow was adjusted to be equivalent to a uniform rate of heat transmission for the tube and fin of approximately 50,000 Btu per sq ft per hr. The electrical resistance between the inner face of the tube and the inside contact plate was uniform and corresponded to a thermal conductivity of approximately 3500 Btu per sq ft per hr per deg F temperature difference. Other sources have indicated this to be somewhat low.

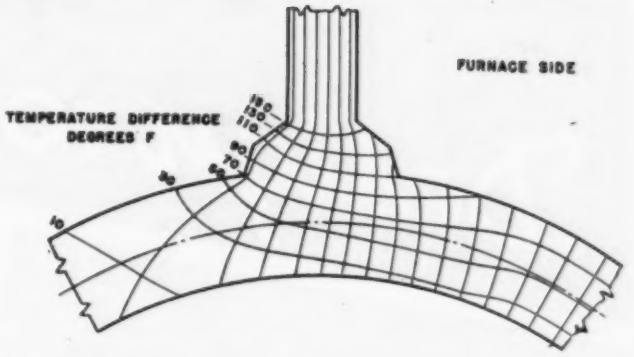

Fig. 6—Temperature distribution and heat flow at base of $^1/_4$-in. × 1-in. fin

The distribution of heat-flux density imposed in the form of current flow was uniform on the circumferential part of the tube and the weld of the fin. The heat picked up by the fin was represented by current flow from the end of the fin only. An examination of the two figures makes it apparent that the only marked difference in temperature drop occurs in the region of the fin and the greatest temperature drops occur with the largest fin. The influence of the fin and the heat it picks up is to change the direction of heat flow from radial to a combination of radial and circumferential. The isotherms instead of being circumferential, dip radially more and more as the circumferential distance increases at or near the fin. Back of the fin in the region where no heat is being added to the tube, the heat flow extends almost 45 deg but the magnitude is very small after about 15 deg have been passed. The fanning out of the lines of flow of the heat, normal to the isotherms, is clearly indicated.

For the experiments, uniform radial absorption has been assumed around the semi-circumference of the tube. This is seldom realized in actual practice, the rate usually being less near the base of the fin. This factor would tend to reduce the heat concentration ahead of the base of the fin and the temperature difference calculated at that point. It does not seem out of place to indicate that under conditions of parallel radiation at any degree of incidence a fin tube will have greater exposure than one of a group of tangent tubes because of their spacing and at some angles the area of the fin will be very important in fixing the heat-flux pattern through the tube because of its proportion to the total.

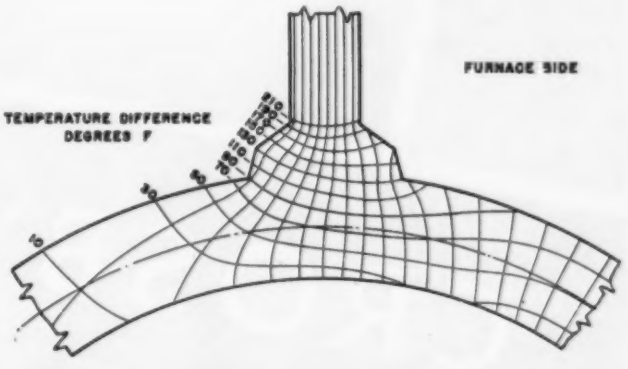

Fig. 7—Temperature distribution and heat flow at base of $^1/_4$-in. × 1 $^7/_8$-in. fin

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Properties of Pure Boiler Feedwater

Because of the avidity with which pure water, such as condensate, takes up impurities, iron and copper from the condenser, the heaters, feed lines and pumps are often taken into solution. This is in the form of ferrous hydroxide which is subsequently broken down, under heat in the boiler, into magnetic oxide of iron, hydrogen and water. It is believed to account for much of the corrosion often found on last-stage turbine blades, in feed pumps, feed lines and the black oxide deposits in boiler tubes.

THERE are two kinds of boiler feedwater: the treated raw water, sometimes also called treated make-up water, and condensates. Both types of boiler feedwater have similar origin and both are the result of condensation.

The raw water results from the condensation of water vapor in the clouds. Condensation comes down through the air as rain drops. These drops are at first pure water but as they pass through the atmosphere they absorb the atmospheric gases such as CO_2, ammonia and oxygen. They also wash down some of the fine particles of dust floating in the atmosphere. When the rain water reaches the ground it runs over and through the surface and is gradually drained into creeks, rivers, lakes and water reservoirs. The depth to which this water penetrates the earth's surface depends largely on the length of the rain period. Pure water is a great solvent. It does not want to remain pure; it wants to hold something in solution. It starts absorbing the gases in the atmosphere and when it runs over the ground it dissolves minerals in the ground and carries them into the rivers, lakes and water reservoirs. The kind and the amount of the minerals it has absorbed depends on the kind of minerals that are held within the surface of the earth with which it comes in contact. The quantity of minerals in solution varies normally from about 50 ppm to 500 ppm. Sometimes it may exceed 1000 ppm.

When this rain water is to be used for feeding boilers the nature of some of the minerals must be changed by treatment, the object of such treatment being to prevent scale and corrosion in the boiler.

Condensate is the steam which is passed through the turbine and is condensed in the condenser. In a modern high-pressure plant the purity of steam is high. The solid impurities in the steam are usually $^1/_2$ ppm or less. High-pressure steam is, therefore, the purest commercial product on earth. Usually impurities in chemicals are expressed in fraction of a per cent, that is, a fraction of a part per hundred. The impurity of steam, however, is expressed in fractions of a part per million. The unity of impurity in the steam, therefore, is 10,000 times smaller than the unit of impurities in chemicals.

The pure steam when it condenses makes very pure water which is very hungry for something to dissolve. It dissolves to some extent anything that it comes in contact with on its way from the condenser to the boiler. This dissolving action starts in the last stages of the turbine where the first condensation occurs. Hence the blades of the last few stages of a condensing turbine are often found to be corroded. This is because they come in contact with the purest water that contains nothing except what little was brought in the way of impurities in the steam. In the condenser the condensate dissolves the iron in the casing and copper from the tubes. More iron and copper is dissolved in the deaerator, feedwater heaters, feed lines and feed pumps.

The temperature of the condensate in the hotwell is generally between 80 and 90 F. This temperature is gradually raised through the various stages of heating so that it is finally within 50 to 75 deg of the saturated steam when it reaches the boiler. As the temperature rises the dissolving action of the water increases. Corrosion of feed pumps is a common complaint in a power plant. The iron content in the feedwater when it enters the boiler runs between 0.1 and 0.2 ppm. When it is picked up by the water the iron is very likely in the form of ferrous hydroxide. The addition of heat causes this ferrous hydroxide to break down into magnetic oxide, water and hydrogen. The amount of hydrogen in the feedwater entering the boiler varies directly with the amount of iron. Generally, about 75 per cent of the hydrogen found in steam comes into the boiler with the feedwater; that is, most of the hydrogen is generated in the feedwater system and not in the boiler. Therefore, hydrogen in the steam cannot be depended upon as an indicator of corrosion within the boiler.

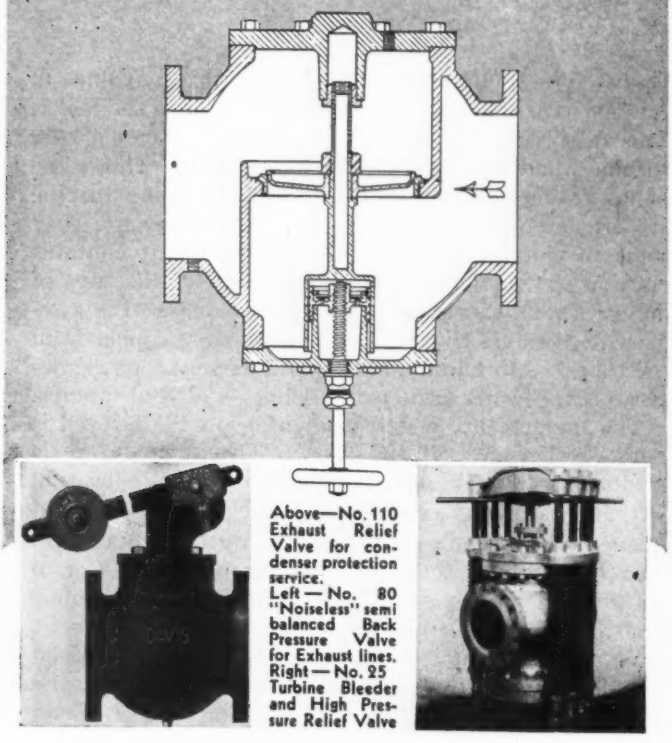
A small part of the iron brought into the boiler with the feedwater leaves in the steam. Generally, the amount of iron in the steam is of the order of 0.01 ppm, although in some cases it may be considerably higher. This iron leaving with the steam can be seen on the turbine blades when the high-pressure turbine is opened. It is in the form of dark gray dust which on exposure to air gradually turns red. However, as it does not form a scale on the turbine blade it, therefore, is not an objectionable content in the steam as are other deposits which accumulate in the low-pressure stages.

Instruments are available for the measurement of hydrogen at any point in the steam cycle. These measure the hydrogen in parts per billion. There are usually about three parts per billion of hydrogen entering the boiler and about four parts per billion leaving the boiler.

Condensate is usually treated with the object of reducing the amount of iron it picks up in the feedwater system. Since the pure water is hungry to have something in solution this hunger is satisfied by suitable chemical. Usually this chemical is sodium hydroxide, the addition of which raises the pH value of the condensate. The pH value of condensed steam is about 7.2. Hydroxide is added until the pH value reaches 8.0 to 8.5. Generally, only a very small amount of the hydroxide is needed to obtain this pH value.

The foregoing explanation is of course aside from corrosion caused by oxygen that may be present in the system.

DAVIS AUTOMATIC RELIEF VALVES



Above—No. 110 Exhaust Relief Valve for condenser protection service. Left—No. 80 "Noiseless" semi balanced Back Pressure Valve for Exhaust lines. Right—No. 25 Turbine Bleeder and High Pressure Relief Valve

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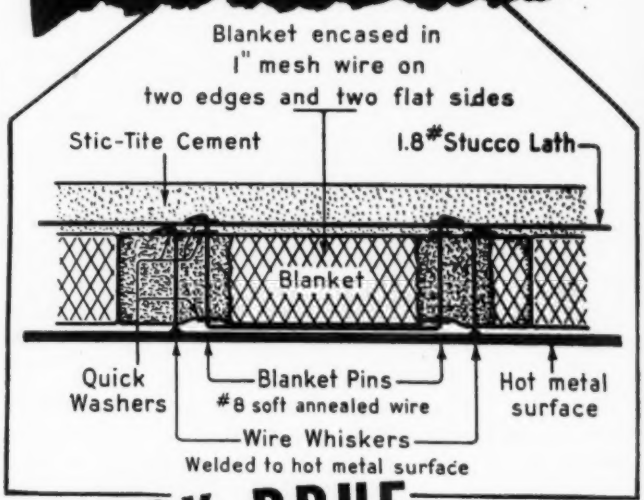
DAVIS VALVES

DAVIS REGULATOR CO.

How to Eliminate Cracking of Finish Insulation Covering on Hot Ducts, Breechings Flues, Tanks, Boilers



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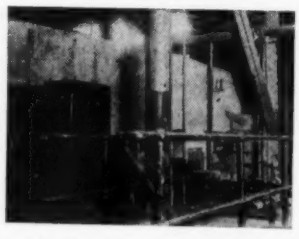
Third—Applying insulating cement over the blanket.

Movement caused by contraction expansion of the duct or flue and even bulging in and out of the metal is absorbed by the blanket and is not transmitted to the lath or finish cement. The cement finish can be smoothly troweled, painted or waterproofed for permanence.



Smoke duct Krack-prufed

Krack-Pruf is an improved method of using blanket insulation so that the finish surface does not crack.

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Measures for Combating the Coal Shortage

NOT only did the protracted cold weather and heavy snow during most of January, and extending into February, seriously slow up transportation and unloading of coal, but the resulting shortage of cars was a factor in slowing down mining operations. Production, during the first three weeks of this year, was more than 4 million tons under that for the same period of 1944 and was considerably below current requirements. Hence, in an effort partly to make up for this deficiency, the Solid Fuels Administration arranged with the miners and operators to work the mines on two Sundays, January 28 and February 11, with the understanding that double time would apply on these days. Despite a record output of approximately 620 million tons of bituminous coal in 1944, due largely to increased mechanization, manpower shortage has been a factor in limiting further production.

There is a critical shortage of coal in certain districts and many war plants, including steel mills, are dangerously low in supply. Therefore, the Solid Fuels Administration recently issued an order prohibiting the shipment of certain scarce bituminous coals from West Virginia, eastern Kentucky and northeastern Tennessee to retail yards in eight north-central states which have other coals available, such as from Illinois and other central parts of the country. By thus cutting off shipments to states having other coals upon which to draw, it should be possible to avert serious hardship in areas completely dependent upon coal from the Appalachian fields.

Since the mid-winter demands are exceeding production by millions of tons, the Government has ruled that users having large stockpiles must supply up to half their current needs from stock. This applies to all bituminous coal produced east of the Mississippi, except the relatively small production in Michigan.

Issued as an amendment to Solid Fuels Administration Regulation No. 23, the new order permits industrial consumers to receive coal covering their full current monthly consumption only if their stockpiles are insufficient to last them more than a specified number of days, which varies according to the source of the coal, its use and the method of transportation. If their stockpiles are less than the specified number of days' supply, industrial consumers are permitted to buy up to 10 per cent more than their monthly requirements, so as to build up their stocks slowly to the minimum safety figure. Those who have more than the specified number of days' supply on hand must reduce their current monthly receipts below consumption by 3 to 50 per cent, as previously mentioned.

Consumers of coal from eastern and southern mines who receive their coal direct by tidewater are permitted to have an additional 10 days' supply.

A detailed breakdown of the new restrictions on shipments to and receipts of coal by industrial consumers is contained in the following tabulations. The first applies to stock limitations on all coal produced in Districts 1, 2, 3, 4, 6 and 13 and high volatile coal from Districts 7 and 8; the second covers low volatile coal produced in Districts 7 and 8; and the third deals with coal produced in Districts 9, 10 and 11.

With reference to domestic consumption, the emergency regulations, announced by the Solid Fuels Administration on January 26, forbid retail dealers to deliver solid fuels to consumers who have more than five days' supply; and to permit deliveries of one ton, or enough to last seven days, whichever is the larger, to consumers having five days' or less supply on hand. The mayors or other chief executives of municipalities were requested to cooperate in making these rules effective by both public and private means, and also to do everything in their power to curtail use of solid fuel by places of amusement, night clubs, libraries and other public buildings. The "Brownout" order which went into effect in many localities on February 1, and by which it is hoped to save some two million tons of coal through elimination of unnecessary outdoor lighting, is another of the measures adopted to combat the present emergency.

TABLE 3—STOCK LIMITATIONS FOR COAL PRODUCED IN DISTRICTS 9, 10 AND 11

Days' Supply	Maximum Percentage of Monthly Consumption Requirements
Less than 21 days	100%
21 to 39 days	85%[a]
40 to 90 days	70%
91 days and over	50%

[a] Industrial consumers having 20 to 24 days' supply may order, in accordance with § 602.514 of this regulation, an amount of coal which will enable them to have on hand a 20 days' supply by the end of the month for which the coal is ordered.

TABLE 1—STOCK LIMITATIONS FOR ALL COAL PRODUCED IN DISTRICTS 1, 2, 3, 4, 6 AND 13 AND HIGH VOLATILE COAL PRODUCED IN DISTRICTS 7 AND 8

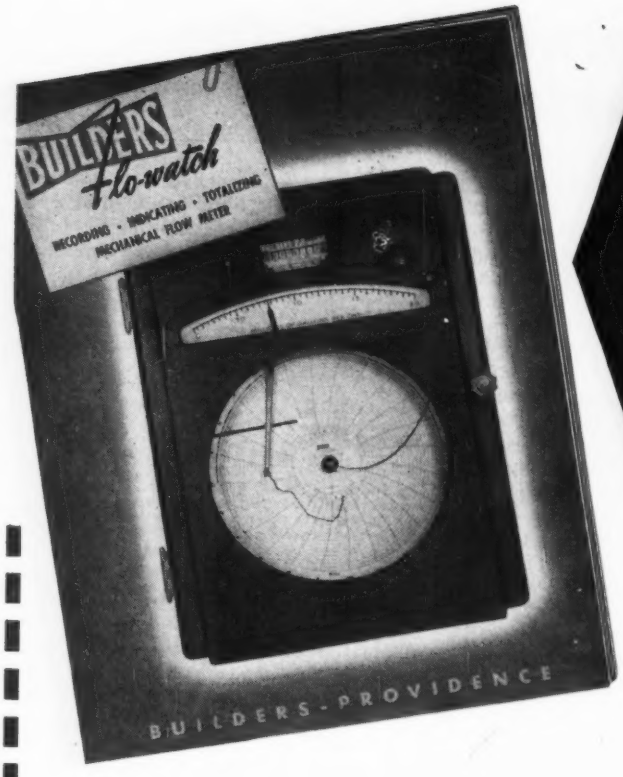
Days' Supply	Maximum Percentage of Monthly Consumption Requirements — Commercial Gas Plants		Public Utilities		All Others	
Less than 15 days	110%	110%	110%	110%	110%	110%
15 to 19 days	110%	110%	110%	110%	105%	110%
20 days	105%	110%	110%	110%	100%	105%
21 to 25 days	105%	110%	105%	110%	[e]	105%
26 to 29 days	105%	110%	105%	110%	[e]	105%
30 days	100%	105%	105%	105%	[e]	100%
31 to 34 days	[a]	105%	105%	105%	[e]	[f]
35 days	[a]	105%	100%	105%	[e]	[f]
36 to 39 days	[a]	105%	[c]	105%	50%	[f]
40 days	[a]	100%	[c]	105%	50%	[f]
41 to 44 days	[a]	[b]	[c]	105%	50%	[f]
45 days	[a]	[b]	[c]	100%	50%	[f]
46 to 50 days	50%	[b]	[c]	[d]	50%	50%
51 to 55 days	50%	[b]	50%	[d]	50%	50%
56 to 60 days	50%	50%	50%	[d]	50%	50%
61 days or more	50%	50%	50%	50%	50%	50%

[a] An amount of coal not in excess of that required to reduce the consumer's stockpile to a 30 days' supply by the end of the month for which the coal is ordered.
[b] An amount of coal not in excess of that required to reduce the consumer's stockpile to a 40 days' supply by the end of the month for which the coal is ordered.
[c] An amount of coal not in excess of that required to reduce the consumer's stockpile to a 35 days' supply by the end of the month for which the coal is ordered.
[d] An amount of coal not in excess of that required to reduce the consumer's stockpile to a 45 days' supply by the end of the month for which the coal is ordered.
[e] An amount of coal not in excess of that required to reduce the consumer's stockpile to a 20 days' supply by the end of the month for which the coal is ordered.
[f] An amount of coal not in excess of that required to reduce the consumer's stockpile to a 30 days' supply by the end of the month for which the coal is ordered.

TABLE 2—STOCK LIMITATIONS FOR LOW-VOLATILE COAL PRODUCED IN DISTRICTS 7 AND 8

Days' Supply	Maximum Percentage of Monthly Consumption Requirements — Railroads and By-product Consumers		Public Utilities		All Others	
Less than 15 days	110%	110%	110%	110%	105%	110%
15 days	110%	110%	110%	110%	100%	110%
16 to 19 days	105%	110%	105%	110%	[e]	105%
20 days	100%	105%	105%	110%	[e]	105%
21 to 24 days	[a]	105%	105%	105%	[e]	105%
25 days	[a]	105%	100%	105%	[e]	100%
26 to 29 days	[a]	105%	[c]	105%	[e]	[f]
30 days	[a]	100%	[c]	105%	[e]	[f]
31 to 34 days	[a]	[b]	[c]	105%	50%	[f]
35 days	[a]	[b]	[c]	100%	50%	[f]
36 to 40 days	50%	[b]	50%	[d]	50%	[f]
41 to 45 days	50%	[b]	50%	[d]	50%	50%
46 to 50 days	50%	50%	50%	[d]	50%	50%
51 days or more	50%	50%	50%	50%	50%	50%

[a] An amount of coal not in excess of that required to reduce the consumer's coal on hand to a 20 days' supply by the end of the month for which the coal is ordered.
[b] An amount of coal not in excess of that required to reduce the consumer's coal on hand to a 30 days' supply by the end of the month for which the coal is ordered.
[c] An amount of coal not in excess of that required to reduce the consumer's coal on hand to a 25 days' supply by the end of the month for which the coal is ordered.
[d] An amount of coal not in excess of that required to reduce the consumer's coal on hand to a 35 days' supply by the end of the month for which the coal is ordered.
[e] An amount of coal not in excess of that required to reduce the consumer's coal on hand to a 15 days' supply by the end of the month for which the coal is ordered.
[f] An amount of coal not in excess of that required to reduce the consumer's coal on hand to a 25 days' supply by the end of the month for which the coal is ordered.



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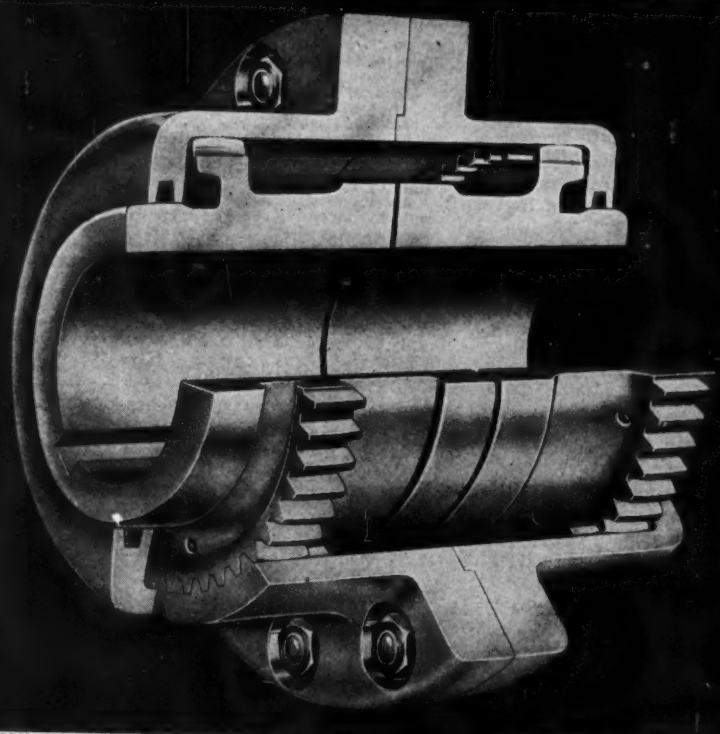
Bulletin 318B describes Builders Flo-Watch Meter. This exceptionally *wide range* recorder is used with a Venturi Tube, flow nozzle or orifice plate for metering the flow of any liquid or gas. Extensively used in steam service where an *hourly chart record* of steam distribution or sale is required. Available as Recorder only, Totalizer-Recorder or Totalizer Indicator Recorder as shown in illustration. For your copy of this Bulletin, address Builders-Providence, Inc. {Division of Builders Iron Foundry}, 9 Codding St., Providence 1, R. I.

Sincerely **BUILDERS-PROVIDENCE**

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

Fuel Selection the Basis for Boiler Plant Design

THE need for power plant designs that will permit greater flexibility in coal selection was stressed by speakers at a meeting of the Metropolitan Section, A.S.M.E. on February 6. This need was shown to be due to the decreasing availability of premium coals, uncertainty in the procurement of selected coals throughout the life of the plant and the wide variation in ash-fusion temperatures. With power plant construction curtailed during the depression years and subsequently by priorities during the war, the post-war era is likely to see much new construction and replacements in this field. Therefore, in view of the changing fuel situation, it was urged that a careful and exhaustive study of available fuels precede all power plant designs.

The first speaker, **J. E. Tobey,** Director of the Fairmont Coal Bureau, New York, stated that surveys of several thousand plants had indicated that not more than 10 per cent of the power and larger heating plants burn a wide range of coals with a high degree of satisfaction and efficiency; about 40 per cent burn a restricted range of coals with varying degrees of satisfaction and efficiency; and the remaining 50 per cent do not burn any type of coal satisfactorily and efficiently.

Responsibility for this situation, he attributed to lack of fundamental information on coals and their availability, to keeping down initial costs, to destructive competitive bidding, to wrong selection of equipment, to divided responsibility, to excessive overloading and to improper coordination of boiler, furnace and stoker or pulverizer. Savings in initial costs, due to some of these practices, are frequently more than offset by increased operating costs in the first year or less.

Of all the mistakes made in the past in the design of boiler plants, the most common and most serious has been failure to allow a reasonable factor of safety in respect to ash-fusion temperature.

In this respect, Mr. Tobey showed that, starting with Iowa and Missouri and moving eastward, every coal field and coal-producing district has low-fusion-ash coals, but only a limited few have high-fusion-ash coals. The fusion range runs from 1900 F to 3100 F, but the average is near the bottom of the range, probably falling between 2200 F and 2300 F. Moreover, the fusion curve is going downward each year because of the faster exhaustion of the limited reserves of the higher fusion coals.

In many geographical areas, including the eastern seaboard, future plants should be designed not only for wider flexibility with respect to ash-fusion temperature but also such factors as grindability, moisture, ash and sulphur content. Instead of designing for an average ash-fusion value, a minimum value should be determined for the coals that will logically be available throughout the expected life of the plant. Grindability ranges from 40 to 115 (Hardgrove Scale) but, as in the case of ash fusion, the average is nearer the bottom of the range and will probably fall around 63.

The second speaker, **E. C. Payne,** Consulting Engineer of Consolidation Coal Company, explained the various production districts as defined by government bodies dealing with coal matters. He showed the range in production costs for these districts and seams, and gave the freight rates to the principal markets. The spread in transportation cost is only 22 cents per ton which is small compared with the spread in production cost. The highest average production cost is in District 7 (Southern No. 1) which amounted to $3.21 per ton for the first four months of 1944. Moreover, the margin between the price of slack and run-of-mine is diminishing ever year. Also as mechanization, which accounts for about 50 per cent of the coal loaded, increases, the ash content will also increase and the customer must expect to pay more for washed coal.

Emphasizing that design specifications for a boiler plant should start with a study of coal data, the speaker showed why primary, secondary and alternative selections should be made, and the final design predicated on the poorest factors in each, that is, the highest ash, moisture and sulphur and the lowest ash-fusion temperature in order to provide maximum flexibility.

The third speaker, **Graham Granger,** Consulting Engineer of Koppers Coal Division, discussed the use of ashless fuel made from coal, namely, manufactured gas. "To make gas," he said, "engineers select sources of coal, mine it, clean it transport it, charge it into an oven, distill a part of the combustible from it, purify the gas and deliver an ashless fuel to the point of use through a pipe line. In many cases the coke that has been produced is charged into water-gas machines, the remaining combustible is gasified, and only the oil remains.

The same thing is essentially true of other coal uses. The fact that in a boiler the gases are immediately oxidized in the combustion chamber and the heat transferred through boiler and other exchanging equipment to water and steam does not alter the basic unity of the problem of providing steam at minimum cost. To secure more efficient results there must be interchange of information among the engineers handling different phases of a job. Those that are designing or operating boilers can better solve their parts of the problem if they know more about the physical and economic conditions that determine the solution of mining, preparation and distributing elements.

DESIGN SPECIFICATION - COAL

Prospective Supply Sources - Destination "X"

Coal Designation		A	B	C	D
(1) Preference Rating		Primary	Secondary	Alternate 1	Alternate 2
Moisture	(Normal Av. A.R.)	3.0	4.5	2.8	5.3
	(Maximum)	8.0	10.0	8.0	10.0
Volatile		31.0	38.0	35.0	38.0
(2) Ash	(Normal Av. A.R.)	8.0	8.5	8.5	10.0
	(Maximum)	10.5	10.5	10.5	12.5
Sulphur	(Maximum)	1.5	3.0	2.0	3.2
B.T.U.	(Maximum)	13,800	13,600	13,300	12,500
	(Minimum)	13,000	12,900	13,000	12,000
A.S.T.	(Maximum)	2,300	2,150	2,400	2,100
	(Minimum)	2,150	2,000	2,200	2,000
Grindability Index		70	55	65	57

(3) Critical Design Factors for Economic Flexibility

Max. Moisture	10	Min. Grindability	50
Max. and Min. Vol.	40 - 30	(2) Max. Size	Crushed R/M (2-1/2 x 0")
Min. B.T.U.	12,000	(2) Min. Size	1/4 x 0"
Max. & Min. A.S.T.	2500 - 2000	Critical Size Consist	70% Minus 1/8"

NOTE:

(1) Based on production cost, transportation cost, chemical, physical and performance characteristics, reserves and availability. Characteristics of plant load may modify.

(2) Ultimate analyses of coal and ash also desirable.

(3) The worst factors should seldom govern absolute designs. Sacrifice some load, if necessary, but avoid outage or shutdown.

(4) Normal size utilized will depend on combustion equipment selected.

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RODA — High grade gas, by-product and steam coal from Wise County, Va., on the Interstate Railroad.

DENDRON — High grade gas, by-product, steam and domestic coal from Wise County, Va., on the Interstate Railroad.

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Admiralty Coal — Genuine New River Smokeless, Beckley or Sewell seam from Raleigh County, W. Va., C. & O. and Virginian Railroads.

Old Kentucky — Hazard No. 4 and No. 7 steam and domestic coal from Wiscoal, Knott County, Kentucky, on the L. & N. Railroad.

CHARMCO — Unexcelled Steaming Coal from the Fire Creek Seam in Greenbrier County, W. Va., originating on the N.F.&G. R.R.

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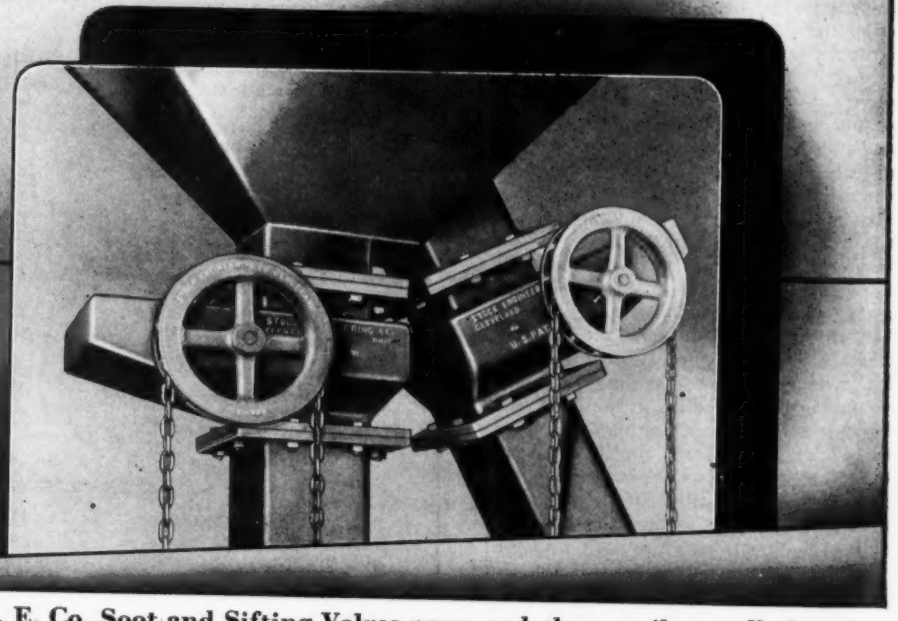

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Ignition Through Fuel Beds on Traveling Grate Stokers

Ignition through fuel beds on traveling grate stokers is essentially underfeed, according to E. P. Carman and W. T. Reid, of the U. S. Bureau of Mines, in a recent paper before the A.S.M.E. That is, up to the point where the ignition plane touches the grate, ignition and burning proceed according to underfeed principles. At constant air rate, underfeed ignition proceeds through the bed at a steady rate unless certain factors alter air distribution or bed characteristics. These factors include: development of blowholes, with consequent maldistribution of air; turbulence or "boiling" of the bed, which may give mechanical mixing of ignited and unignited fuel; slow initial ignition; drying of moist coal before ignition; heating of coal with preheated primary air; and burning of highly reactive fuels in very thin burning layers.

Slow initial ignition of the top layer of fuel is followed by substantially delayed ignition travel through the bed.

Moisture is necessary to temper small-sized fuels, but such moisture tends to retard the rate of ignition and the minimum amount needed to obtain bed stability should be used.

There is an optimum size of particle which gives maximum rates of underfeed ignition. The average optimum size ranges from about $^1/_8$ in. to $^5/_{16}$ in. diameter.

Preheated primary air increases rate of ignition and the increase is proportionately greater at high than at low air rates.

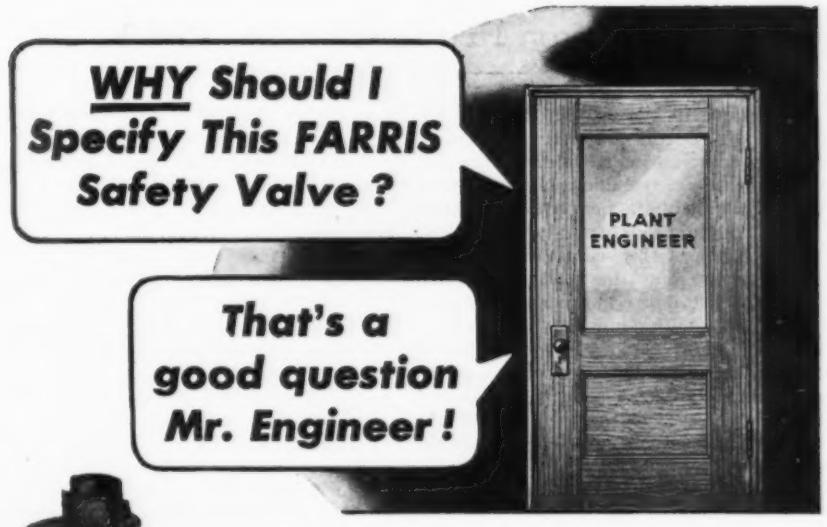
Coal of low ash content has higher rates of ignition travel than similar coal of high ash content, and high ignition rates may be obtained with a much wider range of air rates with the low-ash coal. Burning rates, however, are not materially affected by moderate variation of ash content, and average burning rates do not vary widely for the usual variation of ash content at normal air rates.

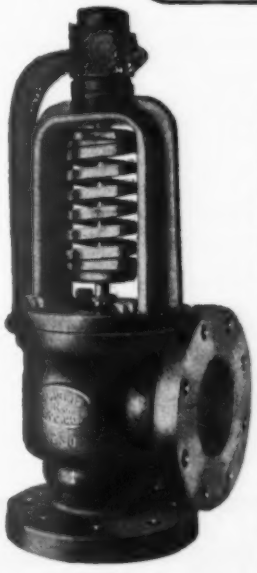
High ignition rates may be obtained with high-temperature coke over a relatively narrow range of air rates, but ignition rates drop very rapidly with increase of air rate over that required to give maximum ignition rate.

Ignition rates as high as those with high-temperature coke may be obtained with anthracite but the range of air rate giving high ignition rates is broader.

The high-volatile bituminous coals give high ignition rates over a very wide range of air rates, but the highly caking types give trouble with air distribution at low air rates.

Sub-bituminous coals and lignite may be burned with a wide range in the rate of air supply, but ignition rates are substantially lower than those of the higher-rank fuels. Because the layer of burning fuel becomes very thin with these fuels, their ignition and burning rates are affected by thermal conditions in the furnace. It would be expected, therefore, that with these fuels maximum ignition and burning rates would be obtained in refractory-lined furnaces operated with high wall and arch temperatures.





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This FARRIS Safety Valve #2350 gives you the advantages of economical first-cost and very low (if any) maintenance expense. It meets ASME specifications. Proven by thousands of installations to be trouble-free, dependable, accurate. Now that's a hard-hitting combination worth specifying!

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The unique design of this FARRIS Valve disc develops a very high coefficient of lift, as established by the National Boiler Laboratories, Ohio State University. The disc entraps the high velocity secured by the full inlet port design, converting the kinetic energy into additional lift for high capacity discharge.

The FARRIS spring—long, exposed, accurately calibrated—controls and regulates the high lift action. It delivers accurate blow-down relief at the exact pressure set for its protection of your equipment.

FARRIS "Precision Alignment" of spring, stem, disc guides, and seat, is accomplished by precision machining—another feature of every finished surface in a FARRIS valve. Through close-tolerance alignment, and sensitive adjustment of the single blow-down ring, precision reseating of the disc on the seat is secured the instant over-pressure is relieved to normal. Thus, non-shock economical blow-down results. You're safe . . . and ahead in all ways—*Always!*—when you specify this FARRIS Safety Valve, Mr. Engineer.

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Energy Production in 1944

According to the Edison Electric Institute, the output of electricity by all agencies contributing to public use totaled approximately 231 billion kilowatt-hours in 1944, a gain of 4½ per cent over that of 1943. This gain took place during the first eight months of the year, as there was a decline in the remaining four months, due largely to curtailment in production of such materials as aluminum and magnesium which required very large quantities of electric energy. Of the total output, approximately 67 per cent was generated by fuel, 32 per cent by water power and less than 1 per cent by internal-combustion engines.

Kilowatt-hour sales were up in practically all categories, particularly domestic and rural customers, as was also total revenue. However, the greater revenues were largely offset by increased expenses, the cost of fuel having been up more than 10 per cent and taxes up 3 per cent over 1943. Taxes, of which two-thirds were paid to the Federal Government, now represent 24 cents out of each dollar received from customers of private electric utilities.

The installed capacity of all electric utility power plants, both private and public, increased during the year by about 1½ million kilowatts, bringing the total present installed capacity up to approximately 50½ million kilowatts. This represents an increase of 11 million kilowatts since 1939 when the war started in Europe. In this same period the output advanced from 126 to 231 billion kilowatt-hours, or 83 per cent while generating capacity increased 28 per cent.

Concurrent peak demands in 1944 reached around 41½ million kilowatts which left a reserve of 21½ per cent above maximum requirements. This figure, of course, represents an average and varied with different systems.

The electricity generated by industrial plants for their own use was estimated by the Institute as approximately 53 billion kilowatt-hours, bringing the total generated, from all sources, during 1944 to 284 billion kilowatt-hours, in addition to about 2 billion imported from Canada.

The foregoing figures are at slight variance with those released by the Federal Power Commission under date of January 24, 1945 which give a total production for public use of approximately 227½ billion kilowatt-hours in 1944, representing a gain of 4.5 per cent over 1943. This may be due, in part, to the fact that the Government's figures do not include plants of small capacity, producing less than 10,000 kwhr per month.

Although this report of the Federal Power Commission does not give the coal rate for 1944, it states that this figure for 1943 was 1.31 lb per kwhr, the same as for 1942 (representing a steady decline from 3.39 lb in 1920). The coal rate varied widely over various sections of the country, due to the grade of coal burned as well as the size and efficiency of the plants involved. The lowest figures were 0.96 lb per kwhr for the District of Columbia and 0.99 lb for Michigan; whereas the highest were 3.99 lb for Wyoming and 2.68 for Mississippi. By regions, the Middle Atlantic and the South Atlantic states showed up best, each being 1.19 lb per kwhr.

A.A.E. Would Amend National Labor Relations Act

Following is a resolution adopted by the Board of Directors of the American Association of Engineers at their December meeting, authorizing a campaign to amend the National Labor Relations Act so as to cover more properly the status of engineers:

WHEREAS, in so far as engineers, architects, chemists and other "technologists," i.e., industrial scientists, are concerned, the Wagner Labor Relations Act has failed utterly to achieve its avowed purpose of "protecting the exercise by workers of full freedom of association, self-organization, and designation of representatives of their own choosing, for the purpose of negotiating the terms and conditions of their employment or other mutual aid or protection"; and

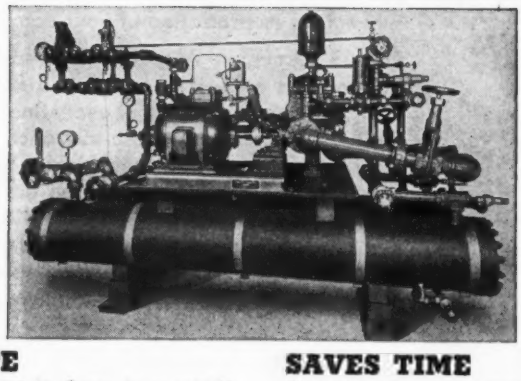
WHEREAS, the Act, as now written and administered, tends instead to amalgamate professional workers in a "labor front," merging technologists and technicians in bargaining units, thereby imposing representation by heterogeneous labor unions committed to bargaining methods and objectives entirely inconsistent with principles of professional conduct and not in the best interest of technologists or society; and

WHEREAS, these conclusions are based on eight years of systematic study of the Act in operation by the Association's Employment and Mediation Committees, whose findings are set forth in the Association's book, "Technologists' Stake in the Wagner Act," published in 1944;

Be It Resolved by the Board of Directors of American Association of Engineers, in session in Chicago, December 8 and 9, 1944, that this Association initiate and vigorously prosecute a campaign for amendment of the Wagner Act that will insure to technologists genuine freedom of association, self-organization, and designation of representatives of their own choosing for the purpose of negotiating terms and conditions of their employment or other mutual aid or protection in a "labor organization" composed exclusively of technologists and controlled by them, in order that they may, in such organization, safeguard their interests and establish procedures of bargaining consistent with principles of professional conduct, and

Be It Further Resolved that American Association of Engineers seek a specific

Enco Automatic OIL PUMPING AND HEATING SYSTEM



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Every detail part is there, in a coordinated design, assembled, checked and tested . . . ready to run.

AUTOMATIC
The Enco Unit is fully automatic . . . and has a safety valve in front of every valve that can be closed against pressure. Single or duplicate pumps and heaters are used . . . interconnected for full capacity from either pump or heater.

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Valuable time and money are saved because the Enco Unit IS a unit . . . complete . . . and can be put in service in a few hours.

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form of amendment that will include these essential provisions:

1. Authorization by Congress (and appropriation of funds necessary for execution of its order) of a complete and detailed classification of all positions in the fields of technology and related mechanical arts, crafts and trades which together constitute industrial science, that will establish a clear statutory line of demarcation between technologists and technicians, i.e., between professional and non-professional workers;

2. A clear directive to the National Labor Relations Board requiring the Board, in its determination of "appropriate units," to permit all technologists (as officially determined by the classification) *to waive or exercise rights of self-organization and designation of representatives, in fully autonomous units, restricted to and controlled by technologists.*

Be It Further Resolved that the Association's Mediation Committee be, and hereby is, directed to plan and put in effect such a campaign.

Sand, a Component of New Lubricating Grease

Although the presence of sand in its natural state has caused incalculable damage to bearings and electrical equipment, when combined with coal, brine and oil to form *silicones* it is destined to make a valuable contribution to both electrical insulating procedures and the lubrication of ball and roller bearings. Such was the prediction made in two papers at the recent mid-winter meeting of the A.I.E.E.

One of these papers, by G. L. Moses of Westinghouse and T. A. Kauppi of Dow-Corning Corporation, explained how the gritty product of American beaches has been chemically treated to become a vital component of soft greases that neither harden at minus 40 F nor melt at 400 F, as well as a basic ingredient of resins and varnishes used for insulation that will stand up under very high temperature.

The second paper, by Messrs. De Kiep, Hill and Moses, all Westinghouse engineers, dealt specifically with the use of the new compounds for electrical insulation. It was pointed out that because of silicone insulation resistance to heat, a reduction in size and weight of electrical equipment can be made for a given output; that greatly increased life can be obtained for the same size and weight; and machines with silicone insulation may be placed in operating locations where surrounding temperatures are higher than heretofore possible.

Other silicone greases now under development are being used successfully for lubricating ball and roller bearings. One type can be employed at a temperature as low as minus 76 F and has high temperature stability at least as good as the best available organic greases. Another type is showing stability in lubricating ball bearings several times as great as organic greases at the same temperature.

STOP
wasting manpower
in the boiler plant
• Here is a clean, automatic system of both coal and ash handling that is complete. Beaumont engineers take full responsibility from design to finished structure including all necessary equipment for handling coal from car to stoker and ashes from pit to truck.
The entire system is designed and built to individual requirements, at reasonable cost. Full details on Beaumont products and materials-handling systems upon request.
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A.I.E.E. Nominations

The National Nominating Committee of the American Institute of Electrical Engineers has nominated the following official ticket of candidates for the offices becoming vacant August 1, 1945:

President: **W. E. Wickenden,** President, Case School of Applied Science, Cleveland, Ohio.

Vice-Presidents: (Middle Eastern District) **Ernest S. Fields,** Vice-President, Cincinnati Gas & Electric Co., Cincinnati, Ohio. (Southern District) **Herman B. Wolf,** Superintendent of Maintenance, Duke Power Co., Charlotte, North Carolina. (North Central District) **L. M. Robertson,** Transmission and Station Engineer, Public Service Co. of Colorado, Denver, Colorado. (Pacific District) **F. F. Evenson,** Consulting Engineer, San Diego, California. (Canada District) **F. L. Lawton,** Assistant Chief Engineer, Aluminum Company of Canada, Montreal, Canada.

For Directors: **John M. Flanigen,** Distribution Engineer, Plant Accounting, Georgia Power Co., Atlanta, Georgia; **J. R. North,** Assistant Electrical Engineer, Commonwealth & Southern Corp., Jackson, Michigan; **W. C. Smith,** Pacific District Engineer, General Electric Co., San Francisco, California.

National Treasurer: **W. I. Slichter,** Professor Emeritus of Electrical Engineering, Columbia University, New York, N. Y.

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Power Extensions Planned for Great Britain

The Central Electricity Board has announced arrangements for large expansion in the generating capacity of selected power stations in England, Scotland and Wales, supplying the Grid, in addition to which several new stations will be built. This expansion in capacity will aggregate over three million kilowatts and has been deemed necessary to meet the anticipated post-war demand for electricity. An estimated expenditure equivalent to around 450 million dollars is involved and construction is expected to be completed by the winter of 1948.

Thirty-eight existing stations are involved, including such well-known plants as Hams Hall, Kirkstall, Valley Road, Fulham and Battersea. A 100,000-kw addition is planned for the last mentioned.

Among new stations proposed are one of 120,000 kw capacity at Meaford in Central England; 90,000 kw at Ipswich and 63,000 kw at Kingston, Surrey; 100,000 kw in Durham and another at Croydon of 105,000 kw initial capacity.

Approvals by the Electricity Commissions have already been given to proceed with the installation of new boilers and turbine-generators which will add some 900,000 kw by the winter of 1946 and a further 340,000 kw during the ensuing twelve months. Directions to undertake the remaining construction are being deferred pending government authority to proceed, although designs and specifications are going forward.

Judging from this announcement, manufacturers of power plant equipment in England face an active period.

Meet the Labor Shortage

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ONE-MAN SYSTEM *for Stockpiling Coal!*

Large Sauerman scraper bucket reclaims five ton load moving across wide storage pile to receiving hopper in about one minute and dumping instantly when it reaches the crater over hopper

ONE MAN does the job! Efficiently and completely. At hundreds of plants, large and small, SAUERMAN Power Drag Scrapers are storing and reclaiming coal at only a few cents per ton.

It's easy! Operator may be in cab at edge of storage area, or anywhere nearby, operating hoist by remote control at finger tip.

Use with any scheme of unloading. Coal delivered at any point in area. Power Drag Scraper does the rest. Forms pile in compact layers. No wasted space. No air pockets in coal pile to cause spontaneous combustion.

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A.S.T.M. Committee Week Canceled—Spring Meeting Deferred

After consultation with the Government's War Committee on Conventions, the American Society for Testing Materials canceled A.S.T.M. Committee Week which had been planned for Pittsburgh, Pa., during the week of February 26. The Spring Meeting of the Society scheduled for February 28 is also being postponed. While much of the committee work deals with production problems involving specifying and testing of war materials, Committee Week would have brought together several hundred persons in one place in a period of three or four days and the Government feels that this is most inadvisable in the present transportation emergency.

Increased Oil Output by Water Flooding

An 87,000-bbl increase in oil production over a period of 20 months was reported for forty-one wells embraced in the first systematic water-flooding project ever tried in an Illinois oil-producing limestone formation, according to an engineering survey just released by the U. S. Bureau of Mines.

Water-flooding is a method of secondary oil recovery in which water is pumped underground to force the oil to the wells where it is brought to the surface. Although tried previously with success in many sandstone formations in Oklahoma, Kansas, Pennsylvania and Illinois, this project marks the first attempt at flooding a limestone formation in Illinois, and one of the few in the nation. The 87,000 bbl was obtained by injecting 1,900,000 bbl of river water into three old wells along the edge of the 13,000-acre tract. Secondary recovery from limestone reservoirs involves problems not encountered in limestone formations.

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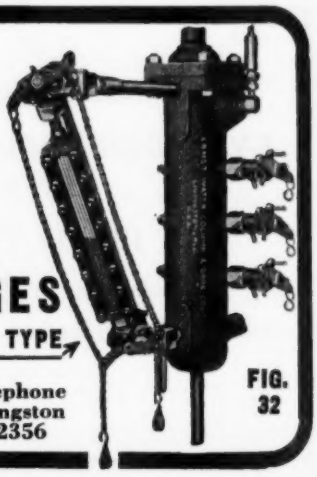

FIG. 1

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FIG. 32

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Electric Power Distribution for Industrial Plants

The American Institute of Electrical Engineers

This report, developed by the A.I.E.E. Committee on Industrial Power Applications, is intended to outline sound engineering principles of distributing power in industrial establishments. The scope of the distribution system includes substations, distribution substations, feeders, circuits, switch centers and protective equipment.

It is not an A.I.E.E. Standard, nor are the recommendations intended to be mandatory or restrictive. Within its scope the report analyzes the service requirements, voltage regulation problems, load characteristics, and it also deals with the selection of equipment for distribution systems. Operating and maintenance problems are dealt with only in so far as they affect system and equipment selection.

The book comprises 109 pages, size $7^3/_4 \times 10^3/_4$, bound in heavy paper covers. It contains 26 tables and 58 charts, diagrams and halftones. Price $1.00.

The Steam Boiler Yearbook and Manual—1944

Edited by Sidney D. Scorer, A.M.I., Mech. E., M.I. Mar. E.

War conditions in England have delayed publication of the 1944 edition of the "Steam Boiler Yearbook and Manual" but have in no way detracted from its scope or interest. The policy of previous editions has been followed; that is, Part I of this volume embodies a descriptive review of current practice in steam-boiler engineering, while Part II contains a digest of the principal steam-boiler Papers published during the past year. It is interesting to note that, in the selection of articles from the technical press, those taken from the pages of COMBUSTION exceed the total of those taken from all the other British and American magazines.

Part I, comprising 472 pages, now consists of 25 chapters. New chapters include: Steam Plant Notes; Boiler Water Level Control Devices; Removal of Boiler Deposits, Heat Conservation; together with Notes on Books and Pamphlets, etc. Chapters on Oil Firing and Gas Firing have been expanded and the remainder have been revised to bring the volume up to date.

Part II comprises 85 pages and includes 23 papers or articles classified under the following chapter headings: Fuel Utilization; Combustion Appliance Developments; Feed Water and Steam Problems; Fire Side Problems; and Modern Practice and Developments.

The book contains 569 pages, size $5^1/_2 \times 8^1/_2$, and includes hundred of drawings, charts and halftones. The price is 30*s*. plus postage ($6.50 approximately; two to three months delivery).

The Modern Gas Turbine

By R. Tom Sawyer, B. of E.E., M. E.

Although the fundamental principle of the gas turbine was known more than 2000 years ago, its development in recent years has been so rapid that no one in the power generation field can afford to ignore its imminent possibilities. For this reason, Mr. Sawyer's book will have particular appeal to those engineers who want to be informed as to the latest applications of the gas turbine as a super charger and as a prime mover.

The author has compiled an authoritative treatise which outlines the earliest concepts of the gas turbine and traces its development from hot air engines built at the beginning of the eighteenth century to modern times. It covers application to supercharge diesel engines and includes chapters on The Gas Turbine in Industry; in Marine Service; and also The Gas Turbine Locomotive. Concluding chapters deal with The Exhaust Turbosupercharger on Aircraft Engines, and The Gas Turbine as an Aircraft Prime Mover, including Jet Propulsion.

A very valuable chapter prepared by Ronald B. Smith on Calculations and Efficiencies, shows that, using the reheat cycle, the gas turbine is by no means a utopian scheme of power generation. It cannot compete with the large modern steam plant for base load use, but with further advances in the metallurgy of high-temperature alloys and further elaboration of the gas turbine cycle, may make possible fuel rates of less than 0.4 pound per horsepower.

The book comprises 216 pages, size 6 × 9. It is generously illustrated and includes three pages of general references and a 10-page index. Bound in green buckram. Price $4.00.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Condenser Tube Inlets

An 8-page illustrated bulletin has been issued by Condenser Service & Engineering Company describing its line of Flowrites—i.e., short auxiliary metal tubes which are inserted in the entrance ends of condenser tubes. The bulletin contains a report by the Massachusetts Institute of Technology of tests made to determine the saving in fluid friction of the circulating water for a surface condenser after equipping the tubes with entrance nozzles.

Gas Engine Compressors

Ingersoll-Rand announces a 16-page catalog (Form 3081) describing KVG Compressors. It lists the basic features and advantages of the KVG, and includes full specifications and 2-page cross-sections of end and longitudinal views. Five models ranging from 600 to 1000 hp are available. The 800-hp model is offered with either two or three compressor frames, the 1000-hp model with three or four. The PKVG gas engine for power needs is a more compact model due to the omission of compressor cranks and frames, and it ranges in size from 600 to 1200 hp in 6-, 8-, 10-, and 12-cylinder models.

Electric Welded Tubing

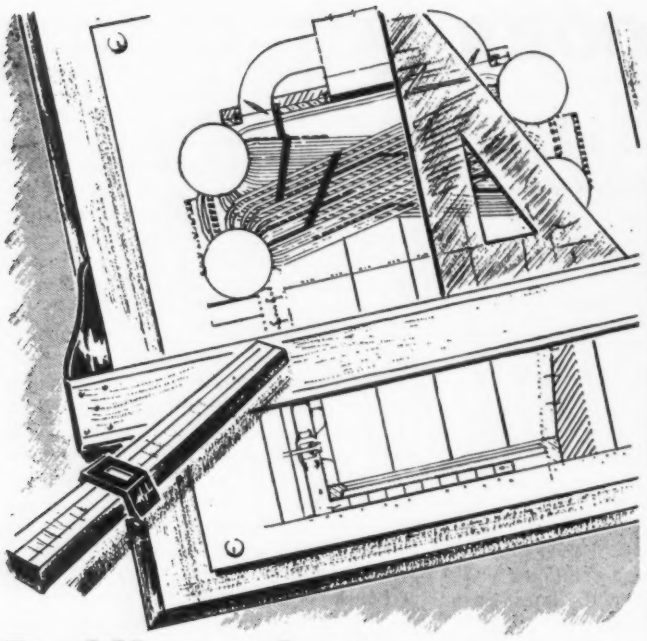
"Better Products with Electric Welded Tubing" is the title of a 32-page booklet issued by the Formed Steel Tube Institute, Cleveland. It was compiled for product designers and is profusely illustrated with pictures of both wartime and peacetime uses of electric welded tubing in its many different forms. The booklet contains specifications for various tubing applications and offers a very complete handbook to engineers who may be interested.

Heat Enclosures

Geo. P. Reintjes Company has issued a 4-page bulletin which outlines the principles underlying its sectionally supported walls. A large cross-sectional drawing shows in color the typical temperature variations in a boiler wall and indicates how Reintjes Construction absorbs and localizes the expansion.

Safety and Relief Valves

Consolidated Safety Valves and Safety Relief Valves are comprehensively cataloged in a new 164-page publication (Catalog 1416) issued by the Consolidated Safety Valve Division of Manning, Maxwell & Moore, Inc. Complete information is given regarding more than fifty types of standard valves together with selection charts and capacity tables. Flange ratings are given and also sizing charts for vapor, gas and liquid. The book also includes excerpts from construction codes and is generously illustrated with line drawings and silhouette halftones.



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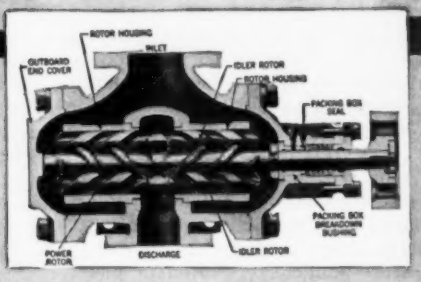

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